THE EAST AFRICAN AGRICULTURAL JOURNAL

of

KENYA
TANGANYIKA
UGANDA AND
ZANZIBAR

Vol. XII—No. 3

JANUARY
1947

Price
Sh. 1/25

IN THIS ISSUE:

As British as the flag

Flying Standard

BRITISH CARS ARE BEST—IN THE LONG RUN

14 H. P.

Four-speed gearbox with synchronized and silent gears on top, third and second speeds. Roomy five-seater body. Electric screen wipers and traffic indicators.

8 H. P.

Superb engine performance. Four-speed gearbox with synchronized and silent gears on top, third and second speeds. Independent front suspension. Triplex safety glass throughout.

Macgregor-Oates Motors Limited

NAIROBI & MOMBASA

District Agents : Boulton's Garage, Nakuru. Pretty Bros., Eldoret. Buck's Garage, Kitale.

THE

EAST AFRICAN AGRICULTURAL JOURNAL

Vol. XII **JANUARY, 1947** **No. 3**

Issued under the Authority of the East African Governors' Conference and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue).

Editorial Board: Directors of Agriculture, Kenya, Tanganyika, Uganda, and Zanzibar.

Editor: Director, East African Agricultural Research Institute, Amani, Tanganyika Territory.

Assistant Editors: P. J. Greenway, Amani; Mrs. M. E. Luckham, Agricultural Department, Nairobi.

Subscription Sh. 5 per volume including postage, payable to the Business Manager, the Government Printer, P.O. Box 128, Nairobi, Kenya. Subscribers are advised to remit postal orders in payment, otherwise bank commission must be added in the case of cheques.

Editorial correspondence should be addressed to the Editor, Amani, Tanganyika Territory.

The Editor does not hold himself responsible for opinions expressed by contributors.

Matter submitted for publication should preferably be sent through the local member of the Editorial Board. Manuscripts, drawings, photographs, should conform with the recommendations contained in *Notes for Authors*, which may be obtained from the Government Printer, Nairobi. *Double spacing should be used in typescript.*

Contributors receive 25 prints of their articles free. Additional copies may be obtained on payment if asked for in advance. Prints bear the same page numbers as the original articles in the *Journal*, except where, to meet a contributor's wishes, prints are supplied before publication has been completed.

Readers are reminded that all agricultural inquiries, whether they relate to articles in the *Journal* or not, should be addressed to the local Director of Agriculture, and not to Amani.

CONTENTS

INDEX TO ADVERTISERS

IMPERIAL AGRICULTURAL BUREAUX

This organization formed by the Governments of the British Commonwealth provides up-to-date information in the form of abstracting and reviewing journals, technical communications and bibliographies on all aspects of science and practice as applied to agriculture, horticulture and forestry.

JOURNALS

The following list comprises journals and other periodical publications. Subscription rates are quoted after each; in certain cases (journal marked with an asterisk) a 20 per cent deduction is made for subscribers in the British Commonwealth who send their subscriptions direct and not through a bookseller.

	£	s.
Bulletin of Entomological Research	1	10
Review of Applied Entomology (Series A)	1	10
Review of Applied Entomology (Series B)		15
Review of Applied Mycology	1	10
*Soils and Fertilizers	1	5
Veterinary Bulletin	2	0
Index Veterinarius	5	0
Nutrition Abstracts and Reviews	2	2
*Plant Breeding Abstracts	1	5
*Herbage Abstracts	1	5
*Horticultural Abstracts	1	5
*Animal Breeding Abstracts	1	5
Helminthological Abstracts	1	10
*Dairy Science Abstracts	1	5
*Forestry Abstracts	1	5

OCCASIONAL PUBLICATIONS, BIBLIOGRAPHIES, ETC.

	£	s.	d.
Some British Books on Agriculture, Forestry and Related Sciences, 1939–45		3	0
A Note on Banana Leaf Speckle in Jamaica and some Associated Fungi		1	3
A Preliminary List of Plant Diseases in the Anglo-Egyptian Sudan		3	0
The foliicolous Ascomycetes, their Parasites and Associated Fungi		18	0
Common Names of Virus Diseases used in the Review of Applied Mycology		5	0
Land Classification for Land-use Planning		4	0
The Spectrographic Analysis of Soils and Plants		4	0
Dietary Deficiencies and Energy Metabolism		1	0
Vitamin B_1 in Cereals		2	6
The New Genetics in the Soviet Union		6	0
The Use of Heterosis in the Production of Agricultural and Horticultural Crops		3	0
The Grasslands of Latin America		7	6
The Forage Resources of Latin America—Peru		2	6
Advances in Grassland Husbandry and Fodder Production—Second Symposium		4	0
Alternate Husbandry		5	0
Imperata cylindrica. Its Economic Significance and Control		2	6
Forest Tree Breeding and Genetics		5	0
The Use of Aerial Survey in Forestry and Agriculture		4	0
The Use and Misuse of Shrubs and Trees as Fodder		6	0
Bibliography of Soil Science, Fertilizers and General Agronomy, 1940–44	1	10	0
Chemical Composition of Plants as an Index to their Nutritional Status		7	6
Fruit Fall and its Control by Synthetic Growth Substances		3	6

All correspondence regarding above journals and other publications may be addressed in the first instance to:—

IMPERIAL AGRICULTURAL BUREAUX,
CENTRAL SALES BRANCH,
PENGLAIS,
ABERYSTWYTH, WALES.

AN EXAMPLE OF CO-OPERATION IN RESEARCH

Plans are now being considered for the reorganization of agricultural research in East Africa, and it is intended that there should be better co-ordination of the work in the territories concerned, as well as a closer link with research stations in the United Kingdom. The scientific isolation of research workers in the tropics has been a serious handicap in the past, and although personal contacts with workers in other countries were easy to make and to maintain, lack of official support prevented full use being made of the willingness of individuals to collaborate. It is therefore of particular interest at the present time to recall an example of co-operation between a colonial government and a research institute in the United Kingdom.

In 1926 the Rowett Research Institute, Aberdeen, started a series of experiments, in collaboration with the Kenya Government, to find the best method of raising the feeding value of the indigenous grasses in Kenya. The scheme was designed by the Committee on the Mineral Content of Natural Pastures, a branch of the Economic Advisory Council in London. Colonel Walter Elliot was Chairman of this research committee, which was composed of scientists and administrators, and Sir John Boyd Orr, then Director of the Rowett Institute, was put in charge of the investigation. It is interesting to note that the scheme was first put forward as a general proposal on 23rd September, 1925; on 25th August, 1926, the research party left the United Kingdom to start the work in Kenya. In the eleven months between these two dates Sir John Orr had visited Kenya and South Africa in a preliminary study of animal nutrition problems in these countries; replies had been received to a questionnaire sent to the Government of India, the Dominion and Colonial Governments and the Government of the Sudan, in order that advantage could be taken of the experience and information available from these sources; the experimental plan for Kenya was drawn up; a grant of £10,000, spread over two years, was authorized from the Empire Marketing Fund; and staff for the field work in Kenya was selected and given a three months' course of special training preparatory to proceeding to Kenya.

The results of the first year's work were so promising that it was decided to continue the investigation beyond the period of two years and to extend its scope somewhat. The Government of Kenya then offered to hand over to the Rowett Institute part of the old Government farm at Naivasha, consisting of approximately 4,000 acres and valued at approximately £25,000, and to make contribution of £5,000 for the purchase of stock and other accessories. A further grant of £15,000 was received from the Empire Marketing Fund. This revised scheme consisted of field experiments in Kenya and in Scotland to demonstrate more fully the results already obtained in correcting the mineral deficiencies of natural pastures by means of a supplementary mineral mixture. Certain aspects of the work were to be investigated at Cambridge University, Aberystwyth, Edinburgh, and elsewhere. The Animal Diseases Research Association for Scotland and the Medical Research Council also agreed to assist on the pathological side.

By the end of 1929 results of considerable importance had been obtained and a comprehensive progress report was prepared by Sir John Orr and Mr. Alexander Holm (then Director of Agriculture, Kenya). This was published as an Appendix to the Sixth Report of the Economic Advisory Council's Committee on the Mineral Content of Natural Pastures (H.M. Stationery Office), in which it was recommended that the work should be continued under Sir John Orr's direction.

The first three years' work, from 1926 to 1929, was briefly as follows. Soil samples and seasonal samples of pasture grasses were collected from Molo, Naivasha, Nakuru, and the Athi Plains, and salt licks in a number of districts were also sampled. Feeding experiments with milk cows, calves and sheep were also carried out at Molo and Naivasha; at Nakuru, oxen were used in a feeding trial on the prevention of the disease known as "Nakuruitis"; and at Doonholm, on the Athi Plains, a small milk yield test was carried out. At Molo, where analysis had shown the grass to be very low in sodium and phosphorus, the mineral supplement (two-thirds bone meal and one-third salt) raised the milk yield, and the growth rate of lambs was increased; the calf experiment gave inconclusive results because of deaths in all groups.

Additional protein slightly increased the effect of minerals. At Naivasha, on the other hand, where the pasture had been found to be deficient in sodium but nearly up to the standard of British cultivated pastures in other respects, the addition of minerals and protein did not cause an increase in milk yield, or in the growth of calves or sheep, although there was a positive result on wool production. The experiments on the Athi Plains could not be undertaken according to the original plan and had to be substituted by two short tests, carried out during the drought, to investigate the effect on milk yield of feeding a high-protein concentrate (simsim cake). In one experiment this supplementary ration caused a milk yield increase of 105 per cent, while in the second trial it gave a 77 per cent increase.

The most striking results were all obtained with "Nakuruitis", the characteristics of which are that grazing animals remain normal for a period of up to six or eight months, after which they become emaciated and show stiffness and lack of co-ordination in movement, with marked signs of anaemia. Groups of oxen were given mineral mixtures containing high, medium and low proportions of iron oxide, and the effects were in proportion to the amount of iron given. The group receiving high-iron mixture were in prime condition at the end of the experimental period, but the low-iron and control groups became so weak and emaciated after eleven months that they had to be given a salt and iron mixture in order to save them.*

In addition to these feeding trials, a test was also carried at Molo on the improvement of pasture by inorganic fertilizers. All treatments caused an increase in growth of grass, the smallest effect being with common salt (25 per cent increase) and the largest with nitrogen plus phosphate (400 per cent). Phosphate-treated pasture remained green during the dry season for a longer period than with other treatments. At the end of the trial stock were allowed to graze on the plots and it was noticed that they grazed the treated plots bare before touching the controls.

Thus at the end of 1929 the experimental work had produced results which were of direct importance to the stock industry in Kenya, and, at the recommendation of Colonel Elliot's committee, a programme was drawn up for two years' further work at Naivasha. In addition to this, the work in Scotland on mineral deficiencies was greatly extended and the co-operation of the Wool Industries Research Association at Leeds was secured in connexion with experiments on the influence of diet on the growth and quality of wool. Digestibility trials with mineral-deficient rations were also carried out at Cambridge University. To the layman the results obtained during this two-year period may not be very striking, as much of the work was designed to confirm or explain the observations made during the 1926-1929 period, but they were of great value in the study of animal nutrition.

In October, 1931, the pasture committee of the Economic Advisory Council produced their Seventh Report, in which the position was again reviewed. At that time there was a grave financial crisis in Britain, and the committee had to take this into consideration in drawing up their recommendations for future work. Reckless economy was the order of the day, and it says much for the strength of their convictions that they put forward strong recommendations against closing down the work, particularly in Kenya. Fortunately, by that time the Naivasha farm was producing revenue sufficient to cover a large proportion of its expenditure, and arrangements were made that it should be carried on, at a minimum cost and more or less on a care and maintenance basis.

Under this new arrangement the Naivasha farm was run jointly by the Kenya Department of Agriculture and the Rowett Institute, partly as a demonstration commercial farm and partly as a research centre. The salaries of two research workers were paid by the Rowett Institute, and it was hoped that the revenue from the farm would be sufficient for maintenance and continuation of the experimental work. Unfortunately, owing to the low market prices which prevailed during the next few years, coupled with unusually low rainfall and locust attacks, the work of the station was severely handicapped and great difficulty was experienced in carrying on experimental work. The investigation of mineral deficiencies, which had been the original reason for the Kenya experimental scheme, tended to drop into the background since the Naivasha pastures were comparatively well supplied with the major elements.

* This disease was subsequently found to be due to cobalt deficiency. The presence of a small amount of cobalt as an impurity in the iron oxide accounts for the success of the high-iron ration.

In March, 1935, the farm was handed back to the Kenya Government, and a grant for its maintenance was obtained from the Colonial Development Fund. It was put under the charge of the Chief Veterinary Research Officer, who reorganized it for research on nutritional and genetic problems of economic importance to the East African territories. It thus became a veterinary research station, with some grass experiments in addition.

Thus co-operative work on a colonial problem, involving a number of research stations in the United Kingdom, is not merely of theoretical interest. It has been done in the past and could be repeated in the future, but the key point is a strong committee in London, with powers to arrange collaboration and to speed up Government procedure. This investigation also shows that time and money can be saved by centralizing parts of the work; for instance, it was not necessary to build, equip and staff an analytical laboratory in Kenya. The analyses were carried out in the Rowett Institute, where laboratory facilities were available and trained staff could be recruited at short notice and on short-term contracts. Applying this to East African agricultural research in general, there is much routine work, in all branches, which could be centralized, even if it meant sending samples or specimens to a laboratory some hundreds of miles away. Shortage of junior technical staff has been a great handicap in the past and is likely to remain so for some years to come.

D.W.D.

A NEW ABSTRACT SERIES—FOREST PRODUCTS AND UTILIZATION

The Imperial Forestry Bureau, Oxford, is publishing a new abstract series on the utilization of wood and other forest products. In the past, *Forestry Abstracts*, the Bureau's quarterly review, has covered the utilization of wood as well as forest policy, silviculture, management, protection and allied sciences. It is realized, however, that the utilization section of the journal is of interest to an entirely different group of technicians, industrialists and research workers, and that it might well be published separately. In future, therefore, section 3 (Utilization) of *Forestry Abstracts* will appear as an extra series under the subtitle *Forest Products and Utilization*. It will provide abstracts of current literature on the properties of wood, harvesting and logging, wood working and products of mechanical conversion, seasoning and drying, chemical utilization, minor forest products and timber constructional works; and also occasional reviews of progress in selected fields of applied research.

The annual subscription to section 3 *Forest Products and Utilization* is Sh. 10; single parts Sh. 3. All correspondence regarding subscriptions should be addressed to: Imperial Agricultural Bureaux, Central Sales Branch, Penglais, Aberystwyth.

NEW SCIENTIFIC BOOKS

The Imperial Agricultural Bureaux have issued the 11th of their series of joint publications entitled *Some British Books on Agriculture, Nutrition, Forestry and Related Sciences*, 1939-1945.

It consists of an Index of Subjects and a list of 28 pages of book titles arranged alphabetically by authors' names, with place of publication, publisher, year of publication, number of pages and often the price of the book. There are about 380 entries.

It was published in July, 1946, and costs Sh. 3 and is obtainable from the Imperial Agricultural Bureaux, Central Sales Branch, Penglais, Aberystwyth, Great Britain.

For those workers in agriculture, nutrition, forestry and related sciences it should be of value in keeping them informed on what British books have been published in their particular subject, but if a scientific worker in the Colonies is to be kept really up-to-date in regard to new scientific books could not the Bureaux publish similar lists more frequently? To my knowledge one of the books listed, it was published in 1940, is now no longer obtainable.

P.J.G.

OIL PLANTS IN EAST AFRICA

(1) Groundnuts, (2) Sesame and (3) Sunflowers

By A. Glendon Hill, B.A., B.Agr., B.Sc., Director, East African Agricultural Research Institute

(1) GROUNDNUTS

The groundnut, or peanut, *Arachis hypogaea*, can be grown as an annual crop in most tropical and sub-tropical countries, its main requirements being a light soil, a hot climate with well defined wet and dry seasons and a rainfall of 25 to 40 inches. Its cultivation in Africa extends from the Gambia across West Africa to Central and East Africa and down to the Union. The plant, which is not found in the wild state but only in the cultivated form, is not of African origin. It is now generally accepted that it was introduced to Africa from Brazil some four centuries ago by the Portuguese, probably not with any altruistic motive but as part of a considered plan for plant introduction as a means of improving native nutrition and so preventing the frequent famines which resulted in lowering the value of their African slaves. Maize, cassava and sweet potatoes are believed to have been first introduced by the Portuguese in the same way. In view of the distinct types found, it is probable that there was more than one importation of groundnuts to Africa from more than one source. Apart from importations, new kinds have probably arisen in the past by mutation and by occasional natural crossings.

The groundnut is a crop of increasing importance to man, its main use being in the production of groundnut oil which is largely used in the manufacture of margarine, cooking and salad oils. Inedible grades of the oil are used chiefly by the soapmaker [23]. Apart from its high oil content of 45 to 50 per cent, the groundnut is a valuable source of protein as shown by the following analyses of shelled nuts from two varieties [23]:—

Variy	Moisture	Oil	Protein	Crude Fibre	Ash
Virginia Bunch	3·3%	45·7	29·5	2·8	3·1
Spanish ..	3·3%	49·1	31·2	2·3	2·7

The residual press-cake left after the extraction of the oil from the kernels forms a valuable cattle food containing about 45 per cent of protein and approximately 6 per cent of oil [2]. It is possible that in future much of this residual press-cake will be used for the manufacture of artificial wool, such as Ardil. Recent progress in the hydrogenation process has made animal and vegetable oils interchangeable to a large extent, thus extending the uses to which groundnut oil can now be put. Apart from the value of the nuts, the groundnut haulms also provide a valuable fodder if properly cured.

In East Africa the crop is widely grown by natives both for food and cash, the bulk of the crop being consumed locally so that only the excess over local requirements is available for export. For some reason the crop has never appeared to attract the European farmer in East Africa, although suitable land is available in many areas and the crop lends itself to large-scale mechanical cultivation.

The great groundnut exporting countries of the world before 1939 were British India, French West Africa and Nigeria. The main groundnut areas of East Africa are the Western, Central, Lake and Southern Provinces of Tanganyika, the Eastern Province of Uganda and the Nyanza and Coast Provinces of Kenya. East Africa exports a comparatively small tonnage of groundnuts, the maximum in recent years being 21,000 tons in 1942, of which Tanganyika contributed about three-fifths and Uganda one-third.

In judging the importance of the groundnut crop in East Africa a distinction must be drawn between the total quantity of groundnuts produced and the quantity exported. Thus in 1936 Tanganyika had an estimated acreage of 290,000 under groundnuts while Uganda had 167,000, but the exports from both countries in that year were only 22,800 and 1,500 tons respectively. It is estimated that in 1944 there were 400,000 growers in the Central, Lake and Western Provinces of Tanganyika alone, each with an average area of 0.42 acres under groundnuts [6].

Of the groundnuts exported from Africa in the period preceding the last war about 40 per cent originated in British and 60 per cent in French territories. Approximately 75 per cent of this export was consigned to France and only about 5 per cent to Britain [13].

Types and Varieties

Groundnut varieties, which are legion, can be divided into three main types: (i) the bunch, or upright, (ii) the creeping or prostrate, and (iii) a type not often seen, where the branches are procumbent but with their ends turned upwards [34]. Intermediate types are also found. The upright type is usually to be preferred to the prostrate since its crop is produced in a compact mass around the base of the stem, thus making harvesting much easier. Other advantages of this type are its earliness and the fact that its pods mature more or less at the same time. The creeping varieties are later and much more difficult to harvest because of their scattered pods. They are also uneven in ripening and yield kernels of unequal size; but against these disadvantages they are said to be little affected by locusts [32]. The types to avoid are those having non-dormant seed combined with a procumbent habit, for with these the losses which may result from an untimely rain at harvest may be serious. Both bunch and creeping varieties can be sub-divided into oil and confectionery, or eating, types, the latter having a characteristic nutty flavour whereas the oil, or crushing types usually have a beany taste. In the U.S.A., where there is a large sale for roasted peanuts, the varieties grown for this market usually contain a lower percentage of oil than those produced for the oil-crushing trade [3].

Groundnut varieties vary greatly in earliness, yield, number of seeds per pod, kernel-colour, shelling percentage and disease-resistance; and to a lesser extent in oil content. The creeping varieties usually mature in four to five months and the bunch varieties a month to six weeks earlier. Most native varieties in East Africa are of the creeping type, but in recent years native farmers in East and West Africa have been taking to the bunch varieties because of their obvious advantages. One of the best introduced upright varieties is Virginia Bunch. This variety, of which there are many selections, is early, drought-resistant, yields well and has a good oil-content. Unfortunately it has certain disadvantages, i.e. a hard shell; a tendency to produce secondary growth should rain fall after a dry spell towards harvest; and, perhaps most important, a tendency for its pods to break off too easily when lifting the crop so that many nuts may have to be left in the ground, particularly when harvesting has been delayed. This last fault is a serious drawback where the crop is ploughed out. Another well-known introduction, popular in Southern Rhodesia, is Spanish Bunch, a variety which is about three weeks earlier than Virginian Bunch but does not yield so well there.

The groundnut responds very markedly to plant selection. All the East African departments of agriculture have carried out groundnut selection for some years past, with notable success in certain instances, e.g. in selecting wilt-resistant strains for the Coast Province of Kenya where Fusarium Wilt prevented groundnut cultivation in an otherwise promising groundnut area. The groundnut being a self-fertile plant the selection and isolation of new strains is a comparatively easy process since the usual precautions necessary to prevent crossing are unnecessary [35]. Selection has been directed for the most part to high yield, high kernel-percentage and resistance to Rosette disease. Selection has not, as far as is known, been carried out in East Africa for evenness in ripening, long dormancy and high oil-content. In Uganda bunch types are being encouraged but at the same time selection is proceeding with the creeping types because of their locust-resistance [32]. In Nigeria one of the problems for the plant breeder is to evolve a bunch type that will yield well on heavy soils and can be lifted by cattle-drawn implements [9].

Groundnut selection has resulted in higher yielding varieties in some areas, but owing to the varying behaviour of different selections depending on season the final choice is difficult. In Nigeria selection over five years resulted in bunch varieties with 25 per cent greater yields and creeping varieties with 16 per cent [35]. The Nigerian variety Castle Cary produced by the Department of Agriculture there is claimed to give an all round yield of 10 per cent over other local varieties in Northern Nigeria and even to have outyielded the Kano creeping types [33]. This variety, which has an excellent flavour, has been introduced into East Africa.

It is probable that selection from amongst existing types in East Africa is a more promising procedure than the introduction of new groundnut varieties from abroad.

Soils and Manures

The best groundnut soils are light, sandy, well-drained loams, not too rich in organic matter. It is sometimes said that groundnuts will thrive where cotton will grow, but in fact the two crops have different require-

ments since cotton is a crop for heavy land. The groundnut is remarkable botanically in that after the fertilization of its flowers their stalks elongate and turn down, pushing the immature seed-pods underground where they complete their growth under the protection of the soil. Because of this peculiarity, a heavy, compact soil is not suited to the crop.

Under native systems of agriculture in Africa the groundnut is seldom manured, but there seems little doubt that could manures be applied, particularly lime, yields would be improved enormously in many areas. Where lime is unobtainable, or prohibitively dear, ant-hill earth from the termitaria of lime-gathering termites might be exploited. It is recorded from Tanganyika that a dressing of 32 tons per acre of such earth resulted in an increase of 96 per cent in the yield of groundnuts [27]. At Serere, Uganda, groundnuts have given no response to lime in field experiments. In Senegal it is reported that lime applied at the rate of three tons per acre gave as much as 35 per cent increase in crop. Such an application, however, would be quite impossible in most native groundnut areas owing to the expense. The same is true of the much-needed phosphatic manures, unless their price can be brought within the reach of the African farmer by developing local sources of supply, such as the phosphate deposits of Uganda.

Cultivation

The groundnut crop should be sown so that vegetative growth is completed during the wet season and ripening in the early part of the dry weather. The normal type of season in the groundnut areas of Africa gives some four to five months of variable rainy weather which enables the native cultivator to raise crops of late maturing runner types which are often sown about a month after the start of the rains and are ready to harvest at the beginning of the dry season.

A severe drought during the growing season may result in a large proportion of "pops" or blind seeds at harvest, the supposed explanation being that the leaves draw on the water of the immature seeds so that they collapse and become incapable of further growth [38].

One of the most important factors influencing the yield of groundnuts is the stand of plants per acre. Close spacing, so as to completely shadow the ground, is to be recommended. In spacing experiments conducted in Tanganyika and Uganda the general result has been to show that close spacing increases yield but that in Uganda it does not pay to sow at a heavier rate than 100 lb. per acre [5] [32]. Repeated trials in Southern Rhodesia with bunch varieties have shown that plants spaced 18 x 6 inches give higher yields than wider spacings [30].

The native farmer sows his groundnuts by hand but, where the area to be sown is too large for this, a modified maize-planter can be used [28], or else a simply made implement known as a knocker-and-dotter [14].

In general practice shelled seed is planted, but in some districts of Nigeria it has been found better to sow unshelled seed some time before the rains break.

Groundnut seed is usually grown at a depth of 1½ to 2 inches on light soils or at 1 to 1½ inches in heavy. The seed-rate may vary from 12 lb. on wide ridges to as much at 100 lb. per acre sown broadcast [5] [32]. To plant an acre of an upright variety, such as Virginia Bunch, at close spacing about 70 lb. of kernels will be required [30].

It is said that one of the essentials of groundnut farming is to keep the soil free of all weeds, but this is not always sound practice. The Uganda native weeds his groundnuts carefully in the early stages of the crop, but as soon as the plants are established weeding is discontinued. Experience has shown that this practice is sound in that the ground-cover of groundnuts plus weeds assists in keeping infection by Rosette disease to a minimum; in fact, one of the essentials of successful groundnut cultivation in Uganda is to establish and keep a complete cover of vegetation over the soil, either of the crop itself or of groundnuts plus weeds [32]. In this connexion experiments have been carried out with grass-mulch and delayed weeding to observe the effect on yield and the incidence of disease. It is doubtful, however, whether mulching of groundnuts would pay for the labour involved.

The groundnut is an adaptable crop and will readily fit into a large variety of rotations. It is a good preparatory crop for maize. In East Africa its place in the rotation varies from district to district; thus it may be sown on newly-cleared land or else as the last crop in four-year rotation after cotton. Frequently, however, no definite place is assigned to it in the rotation, the crop being interplanted with maize, millets, cassava or cotton. This practice applies more to those areas where a small quantity of nuts is grown for home consumption; in the important groundnut areas most of the crop is grown in pure stands. In the

Central Province of India a three-course rotation of cotton, sorghum and groundnuts is said to give the best financial return [25].

Harvesting and Shelling

The harvesting of groundnuts by hand is a tedious and lengthy operation, particularly with the spreading varieties, and may absorb more labour than planting and cultivation combined [11]. In fact, one of the main drawbacks to this crop from the native's standpoint is this irksome business of harvesting. Natives are extremely fond of groundnuts, which, added to their porridge in the form of relishes, provide a welcome addition to a monotonous starch diet, and the fact that they do not grow more is possibly related to this difficulty of harvesting the crop. The planting of bunch types reduces this labour considerably, sometimes by half.

Because groundnuts do not ripen evenly harvesting must be done when the majority of the pods are mature, that is when the kernels loosen in their pods and the veins on the inside of the shells begin to colour. Early harvesting, even a week before the kernel is mature, affects quality since it enhances the free-fatty-acid content and reduces the oil-content [26]. On the other hand, if harvesting is delayed too long the kernels may germinate in the shell before lifting.

In the traditional African method of harvesting groundnuts the plants are simply hoed up by hand, exposed root upwards to the sun to dry and the nuts picked by hand. Where working oxen are available much manual labour can be saved by ploughing out the crop, using a single-furrow plough with its mould-board removed. If the vines are buried in lifting the crop they may become too sandy to be used as fodder with safety. In India the use of a combined groundnut lifter and plough is claimed to reduce the cost of harvesting by over Sh. 7 per acre, while at the same time leaving the land ready ploughed for the next crop [25]. In the U.S.A. special machinery is employed for lifting, picking and shelling the peanut crop. There, after the crop is lifted, the vines, with nuts attached, are cured together by piling them in tall, narrow stacks built around 6 ft. high stakes on which cross cleats are nailed in such a way as to keep the plants aerated and off the ground These stacks are protected with paper caps or other form of protection from rain. When cured the nuts and vines are separated mechanically.

If large-scale production of groundnuts by mechanized agriculture is to be undertaken in East Africa the choice of varieties will be of special importance, since a variety in which ripening is very uneven and in which the pods break easily from the vine during harvesting may result in considerable loss of crop.

Groundnuts for export are usually marketed shelled or decorticated, as only the best kinds for the edible trade will stand the high transport costs on unshelled nuts. Shelling as carried out by native methods is a primitive process, sometimes done by beating with sticks but more often by pounding in a native mortar and pestle. Either method results in a large proportion of broken kernels which lowers the value of the product. Efficient shelling machines are available and have been introduced into some native groundnut areas.

The percentage of kernels to nuts is usually about 70 per cent but may vary between 65 and 75 per cent, according to variety and other factors.

The yield from groundnuts as grown by African farmers varies enormously with rainfall, soil and other factors, the figure probably ranging from 200 to 2,200 lb. per acre of unshelled nuts. In the Western Province of Tanganyika the average yield per acre is estimated at approximately 600 lb. (unshelled), while in Uganda the figure is said to be 600 to 700 lb. In the great groundnut area of Northern Nigeria the average yield is between 500 and 600 lb. per acre (unshelled), but yields of a ton or more per acre are sometimes recorded [9]. These figures for native production are low compared with, say, Australian yields where under mechanized agriculture in Queensland yields of 3,600 lb. per acre (unshelled) are recorded under ideal conditions, the average being about 1,500 lb. [7]. In the U.S.A. approximately 4¼ million acres of peanuts were grown in 1944, the average yield from the three million odd acres harvested and not eaten off by pigs being 670 lb. per acre (shelled) [37].

Groundnuts are not normally a difficult crop to store in East Africa. Provided that they are kept in the shell and thoroughly dry before storing they should keep for at least two years. In Senegal, however, a moth, *Ephestia*, causes great losses in groundnut stores. This pest could probably be kept in check by controlling the humidity of the warehouses.

In Nigeria produce inspection at the godown, introduced in 1936, has done much to improve and maintain the quality and purity of the groundnuts exported. The onus of seeing that the kernels are up to standard is placed on the buyers and exporters who consequently are careful in what they buy from the native grower. The cost of the scheme is borne by an inspection fee of threepence per ton on all nuts railed for export.

Groundnut seed-stocks should be stored in the shell, otherwise germination of the seed is usually low.

Diseases and Pests

Fortunately the groundnut is not one of those crops which suffer from innumerable pests and diseases. However, it has its diseases, the most important of which in East Africa are Rosette, Leaf-spots and Wilt. Rosette disease, which is the most important of these, was first discovered in 1907 by Zimmerman in what is to-day Tanganyika Territory. If uncontrolled, this virus disease can be really serious, in fact in at least one district in South Africa outbreaks of Rosette disease led to the crop being abandoned. The disease is transmitted to the plant by an insect, *Aphis laburni*, and at least six types of the disease are known [32]. The incidence of Rosette disease varies enormously from season to season, but so far no correlation with climate has been established. Close spacing of the plants has proved to be the most successful control method, the supposed explanation being that the aphid which transmits the virus is subject to the attacks of a fungus and that with open planting sufficient aphids escape the fungus to carry the virus extensively through the crop. The effect of close planting is to alter slightly the microclimate existing amongst the foliage of the groundnuts and this slight change gives the fungus the upper hand so that the aphids are kept in check. The Uganda natives' method of close planting is a near approximation to the ideal for controlling Rosette disease. Apart from close spacing, there are other controls which can be adopted, such as the sowing of resistant varieties, early planting, the adoption of a uniform sowing date throughout a district, allowing a reasonable weed growth after the crop is established and, lastly, the destruction of all self-sown plants during the off-season. In mechanical cultivation where the rows are more than one foot apart Rosette disease is likely to cause trouble.

The leaf-spot diseases, *Cercospora personata* and *C. arachidicola*, can both be destructive, particularly on newly introduced varieties. The two diseases are so similar as to be indistinguishable excepting by microscopic examination. The selection of resistant strains, which are known to exist in the case of *C. personata*, would seem to be the best means for controlling these diseases. As an alternative, dusting with sulphur or copper-sulphur, or spraying with Bordeaux mixture can be effective as a means of control and may prove necessary in East Africa should groundnut cultivation be taken up on a plantation scale, as proposed.

Wilt disease. Three fungi are known to cause wilt; (i) a *Fusarium* species, (ii) *Rhizoctonia bataticola* and (iii) *Sclerotium rolfsii*. The first-named of these is serious in the Coast Province of Kenya, where it is a limiting factor in groundnut production. Fortunately, resistant varieties have now been isolated [20] [21].

The disinfection of seed with mercurial dusts is recommended in Southern Rhodesia as a means for controlling seed-rot and root-rot, or wilt (*Sclerotium rolfsii*) [18].

Insect pests. Of these the most important is *Aphis laburni*, the vector of Rosette disease. Another pest is a small ant (unnamed) reported from Uganda which bores into the pods underground and eats the developing seed.

Apart from insects there is another pest, a yellow flowered parasitic weed, *Alectra abyssinica*, which is very destructive to groundnuts and other legumes in parts of Tanganyika, where it is a notifiable pest.

Economics

The only published cost of production figures for native-grown groundnuts in East Africa would appear to be for Uganda [39] and the Eastern Province of Tanganyika [11]. In the latter the comparative cost of groundnut, cassava, sorghum and cotton production in 1939 is given as follows, costs being in man-days:—

	Clearing	Planting	Weeding and thinning	Harvesting	Uprooting	Total
Groundnuts	8¼	11*	11	28	—	58½*
Cassava ..	12	12	9	19	—	52
Sorhgum ..	6	4	6½	6½	—	23
Cotton ..	11	5	12	12	2	42

Note.—Author explains that this figure could be reduced by 4 man-days.

The cost of production figures for Uganda in man-days are considerably higher, being given as follows in 1932: ploughing and harrowing 4, planting 11, weeding 12 and harvesting 118; or a total of 145 man-days [39]. The figure of 118 man-days for harvesting in Uganda is extremely high compared with 28 man-days in Tanganyika and about 32 man-days for the West Indies.

Comparative cost of production figures for groundnut and cotton in the Central Province of India in 1934 are given as Sh. 45 and Sh. 30 per acre respectively, but where the groundnut crop is ploughed out the cost can be reduced by about Sh. 7 per acre [25].

The world demand for edible oils was probably never greater than it is to-day, when the deficit is said to be of the order of a million tons, while the world supplies of oils and fats for 1946-47 are estimated at half the pre-war figure (Cmd. 6879). British India, which before 1939 was the greatest exporter, is unlikely ever to resume its groundnut export trade on the pre-war scale; its population increases so rapidly that the country will probably require all the food it can grow. Consequently the world demand for African groundnuts is likely to be keen for years to come, while the African continent itself will probably need increasing quantities for home consumption or manufacture. South Africa alone used to import yearly 50,000 tons of groundnut oil from India, a source of supply now denied to her, so that the Union is at present faced with the task of producing an additional four million bags, or 178,000 tons, of groundnuts per annum to make good the deficiency.

The possibility of developing the groundnut export industry in East Africa would appear promising since suitable conditions for the crop exist over wide areas of the country from sea-level to 4,000 ft. a.s.l., particularly in Tanganyika. The expansion of the industry in East Africa would seem to be largely a matter of man-power and economic transport. It was not until the railway was built from Lagos to Kano, 700 miles inland, that the great groundnut industry of Northern Nigeria was developed, an industry which exports as much as 325,000 tons of nuts per annum.* A native groundnut export industry could not develop, even in the most suitable areas, unless adequate transport is available, since the African will not carry heavy headloads over long distances. If means of transport are inadequate it is said that he usually prefers to grow cotton.

Because of the expanding world demand for edible oils and proteins it is highly probable that the groundnut will play an increasingly important part in native, and perhaps estate, agriculture in East Africa.

LITERATURE

[1] Barker, J. (1943).—"Part played by Legumes in Diet of Nyasaland African", *E. Afr. Agr. J.*, 8, 212.

[2] Bolton, E. C.—*Oils, Fats and Fatty Foods*, London, 1928.

[3] Burkill, I. H.—*Dictionary of Econ. Products of Malay Peninsula*, London, 1935.

[4] Chevalier, Aug. (1933-36).—"Monographie de l'Arachide", *Rev. de Bot. Appliquée*, Vols. XIII, XIV and XVI.

[5] Clarke, W. C. (1937).—"Close Planting of Groundnuts", *E. Afr. Agr. J.*, 2, 380.

[6] Department of Agriculture, Tanganyika.—Pamp. 41, Dar es Salaam, 1945.

[7] Department of Agriculture and Stock.—Q'land Agr. & Pastoral Handbook, Vol. I, Brisbane, 1941.

[8] Ejercito, J. M. (1934).—"Plants in the Philippines", *Phil. J. of Agr.* 2, 2, p. 47.

[9] Faulkner and Mackie.—*West African Agriculture*, C.U.P., 1933.

[10] French, M. H. (1934).—Ann. Rept. Vet. Dept., Tanganyika, 1934.

[11] Fuggles-Couchman, N. R. (1939).—"Some Production Cost Figures for Native Crops in Eastern Province of Tanganyika Territory", *E. Afr. Agr. J.*, 4, 396.

[12] Greenway, P. J. (1945).—"Origins of Some E. Afr. Food Plants", *E. Afr. Agr. J.*, 10, 253.

[13] Hailey, Lord.—*African Survey*, O.U.P., 1938

[14] Hartley, B. J. (1936).—"Groundnuts and Their Cultivation", *E. Afr. Agr. J.*, 1, 501.

[15] Hayes, T. R. (1937).—"Some Aspects of Groundnut Production", *E. Afr. Agr. J.*, 2, 455.

[16] Hennefrund, H. E. (1939).—"A Sel. of Ref. on Ec. Aspects of Peanut Ind.", 1920-39, Agr. Ec. Bib. No. 80, Bur. of Econ., U.S.D.A.

[17] Hill, A. G. G. (1938-44).—"Précis of Work Done for Improvement of Native Food Crops in East Africa", Circulars of E. Afr. Agr. Res. Inst.

[18] Hopkins, J. C. F. (1945).—"The Importance of Seed Disinfection of Groundnuts", *Rhod. Agr. J.*, 42, 5.

[19] Hosking, H. R. (1938).—"Improvement of Native Food Crops by Sel. and Breeding in Uganda", *E. Afr. Agr. J.*, 4, 86.

[20] Humphrey, N. (1939).—"A Groundnut Wilt Disease on the Coast of Kenya", *E. Afr. Agr. J.*, 5, 110.

[21] Humphrey, N. (1942).—"A Note on Groundnut Sel. Work", *Ibid.* 7, 220.

* The average cost for transport and handling between the Nigerian groundnut areas and the coast for the period 1928-37 was £4-10-0 per ton.

[22] Ireland, de C. (1941).—"The Storage of Native Food Crops in Uganda", *E. Afr. Agr. J.*, 7, 74.

[23] King, J. G. M. (1939).—"Mixed Farming in N. Nigeria", *E. Afr. Agr. J.*, 7, 271.

[24] Jamieson, G. S.—*Veg. Fats and Oils*, New York, 1932.

[25] Mahta, D. N. (1934).—"Harvesting of Groundnuts", *Emp. Cotton Growing Rev.*, 11, 209.

[26] Patel, J. S. (1935).—"Oil Formation in Groundnuts with Reference to Quality", *Ind. J. Agr. Sc.*, 5, 165.

[27] Rounce, N. V. 1939).—"Ingereza Ng'wana Sweya, etc.", *E. Afr. Agr. J.*, 5, 211.

[28] Sellschop, J. (1942).—*Farming in South Africa*, 17, 651.

[29] Storey, H. H. (1935).—"Virus Diseases of E. Afr. Plants—III, Rosette Disease of Groundnuts", *E. Afr. Agr. J.*, 1, 206.

[30] Timson, S. D. (1945).—"The Groundnut", *Rhod. Agr. J.*, 42, 5.

[31] Tomlinson, F. R. (1936).—"Business Side of Peanut Farming", *Bull.* 177, Dept. of Agr. and Forestry, S. Africa.

[32] Tothill, J. D.—*Agriculture in Uganda*, O.U.P., 1940.

[33] Turner, R. (1940).—"Some Economic Aspects of Groundnut Industry in N. Nigeria", *Emp. J. Exp. Agr.*, 8, 39.

[34] Sampson, H. C.—"Cult. Crop Plants of British Empire", *Bull. Misc. Inform. Kew*, H.M.S.O., 1936.

[35] Worthington, E. B.—*Science in Africa*, O.U.P., 1938.

[36] Anon. (1933).—"Groundnuts in S. and E. Africa, results of analyses, etc.", *Bull. Imp. Inst.*, 31, 150.

[37] Anon.—Agricultural Statistics, 1945, U.S.D.A., Washington.

[38] Anon. (1943).—*Bull.* 213. Georgia Expt. Sta., U.S.A.

[39] Anon.—Ann. Repts., Dept. of Agr., Uganda, Pt. II, 1929-1931.

(2) SESAME

(*Sesamum orientale*)

Sesame or simsim, also known as *Ufuta* (Kiswahili), gingelly, bene or til, probably originated in Africa since its allied wild species are only found in this continent [23]. It is cultivated as a food crop throughout the hotter and drier parts of Africa and extends from the shores and islands of the Mediterranean across Asia Minor to India, China, Manchuria and Japan. Its cultivation in these zones dates from time immemorial [11] and the fact that the Sanskrit word for oil and for the seed of this plant are synonymous suggests that it may be one of the earliest oil-bearing plants to be brought under cultivation [18]. The plant must have found its way from Africa to Asia at a very early date, for India, Burma, China and Japan all have developed many distinct and specialized varieties [23]. The importance of the crop in Asia may be judged from the fact that in India alone the estimated area under sesame is over four million acres. Africa as a whole produced only about 8 per cent of the world's crop in 1938 [9]. Sesame seed is chiefly valued for its excellent edible oil which is used for culinary purposes and in the manufacture of margarine, salad oils, shortenings, etc. [13]. The seed is also used to some extent in various kinds of confectionery. At one time Continental countries required that margarine should contain 5 to 10 per cent of sesame oil in order to facilitate the detection of margarine as an adulterant of butter by means of Boudouin's test, whereby even small amounts of sesame oil can be readily detected [5] [13]. Apart from its use as a source of edible oil, sesame seed, which has a pleasant milky flavour, enters into the African's diet in various forms such as in porridge, soup, etc. Both seed and leaves are used as demulcents and for other medicinal purposes [13]. The following analyses [24] of sesame seed, whole and decorticated, show that, apart from its high oil content, sesame is rich in protein, calcium and phosphorus. The calcium content is notably high but most of this is contained in the seed-coat and so is lost when the seed is decorticated:—

	Water	Protein	Fat	Total Ash	Crude Fibre	Carbohydrates	Calcium	Phosphorus
Whole seed ..	5·8%	19·3	51	5·7	3·2	18	1	0·7
Decorticated seed	—	—	—	3	—	—	0·08	0·68

The main sesame producing areas of East Africa are: the Southern Province of Tanganyika, which supplies most of that territory's production [25]; the Northern Province of Uganda and the Nyanza Province of Kenya [9]. Although widely grown in East Africa, sesame exports do not reach a high figure for the reason that the crop is used for the most part, with groundnuts and coco-nuts, to provide the oil portion of the African's diet. Apart from the few areas where the crop is grown for sale, sesame is as a rule merely one of the numerous minor crops grown by the native farmer on a garden scale for his domestic use. The amount sold for export varies

from year to year and depends largely on the weather, the market price and the amount of the crop retained for local consumption. The average annual exports of sesame seed and oil in tons from East Africa for the five years 1935-39 were:—

Kenya		Tanganyika		Uganda	
Seed	Oil	Seed	Oil	Seed	Oil
1,601	368	4,671	64	1,542	26

It is particularly important that sesame for export should be free from contamination by the wild *Sesame radiatum* (*Ufuta mwitu*), the seeds of which, besides containing a lower percentage of oil and protein, yield an oil-cake which is reported as being toxic to cattle. [27]. The seeds of *Sesamum orientale* and *S. radiatum* are closely alike in size and shape, but the latter has raised veins, or reticulations, on the surface of the seed whereas *S. orientale* has a matt surface.

Types and Varieties

Great variation is often to be seen amongst the plants of a normal crop of sesame as grown in East Africa. In spite of its wide area of distribution comparatively little attention has been given in sesame-growing countries to the study of varietal differences in the crop [11]. For commercial purposes sesame is broadly divided into white- and black-seeded types, the former commanding the higher price. The oil content of the whole seed varies from 48 to 54 per cent and occasionally is as much as 58 per cent [5]. The black-seeded types contain the most oil, but that from the white-seeded is superior in quality [5] [13]. Between these extremes of black and white one finds a range of colours from dark brown to red. Apart from seed colour, much variation is to be seen in the habit of the plant and in its height and earliness. Two definite types of root formation have been observed which may be of major economic importance since they are associated with the habit of the plant and the time it takes to reach maturity [11]. At least twelve distinct varieties of the crop are recognized by the Lango of Uganda, each with a descriptive name referring to colour, hairiness, shape of capsule, etc., while in Buganda five main types are recognized, one with eight locules [17]. There are indications that in India and Africa sesame varieties have developed which are peculiarly suited to local conditions and that such varieties do not thrive when introduced to another district or country [1] [17]. Of numerous varieties introduced into Uganda from India and the Sudan none proved as good as those already established in the country [17].

Crop Improvement

It has been suggested that the selection of sesame on too narrow a basis is unlikely to prove advantageous and that a judicious mixture of types with free intercrossing to maintain vigour and to prolong the pollination period is to be preferred [10]. This is a doubtful hypothesis, particularly since the amount of natural crossing in this crop is believed to be small for the reason that the anthers burst in the bud shortly before the corolla unfolds, while at the same time the stigma becomes receptive so that it is covered with pollen at the time the flower opens. However, there is a possibility of a certain amount of natural crossing by insects owing to the occurence of abortive stamens in some flowers [11]. In Uganda selection has been carried out mainly with the object of isolating high-yielding, white-seeded types for export and has resulted in the establishment of improved forms. Efforts have also been made there to isolate a pure strain with eight locules which is thought likely to be a heavy yielder [17]. Selection for resistance to leaf-spot diseases is also important as is selection for early maturity, a factor which tends to reduce damage by gall-midge (*Asphondylia*) and other insects [17]. In Tanganyika selection has been carried out for a number of years in the Southern Province with the object of improving yield and colour of seed [25]. Some improvement has been effected in seed colour and experience has shown that it is a fairly simple matter to obtain a pure supply of white seed which breeds true [2]. In California and Arizona the United States Department of Agriculture has attempted to develop non-shattering varieties. If these could be developed there is a possibility that the crop might be a commercial success under mechanized agriculture in the warmer parts of the U.S.A. and elsewhere.

Soils and Climate

Although sesame is somewhat particular in its growth requirements it will grow on a wide range of soils from light to heavy, provided that the rainfall is moderate and no water-logging takes place. The crop does not thrive on acid soils nor on those in which it is impossible to obtain a good surface tilth [16].

In Tanganyika the crop grows best in deep, dark, alluvial soils, though the coastal plain soils also produce excellent crops [25].

Sesame is generally regarded as a crop which exhausts the fertility of the soil more than most, but experiments in Nigeria have not confirmed this belief [8].

Being shy of excessive moisture, the seasonal limits of sesame are controlled by rainfall as well as temperature [11]. The crop is sensitive to adverse soil and climate with a result that variation in yield is considerable between adjacent plots and from district to district. This tends to make the crop a chancy one and difficult to experiment with [17].

Cultivation

In the Southern Province of Tanganyika sesame is usually interplanted with sorghum or maize and is sown in February when all other crops are already in the ground [25]. In the North Lango district of Uganda the crop is usually sown in the second rainy season when it succeeds finger-millet (*Eleusine*) in the second year of the rotation and sorghum in the third year [17].

The seed is usually sown broadcast, the seed-rate being about 8 to 10 lb. per acre [15]. A fine soil tilth is necessary. Sesame seed being very small much of it is lost on sloping ground after heavy rain. Natives in the West Nile district of Uganda prevent this by allowing grass to grow after preparing the land and before sowing their sesame. After the sesame is well up the grass is removed as well as possible [17]. Weeding in broadcast plots can be done only in the early stages of growth after which no further attention, apart from thinning, is normally given till harvest.

Harvesting and Threshing

Sesame, like such oil-seeds as groundnuts and sunflower, is not an easy crop to harvest. This is because the seed capsules develop and ripen over a considerable period so that one may find plants with ripe pods below, green ones in the middle and flowers at the top. The crop is usually ready to harvest when three or four months old, the plants being cut when the majority of their leaves have dropped and the earliest seed capsules are dehiscing. At this time most of the capsules may still be green, but it is inadvisable to leave the crop to ripen fully because of the danger of loss from shedding [16]. In the usual method of harvesting the whole plants are cut, tied in small bundles and hung on sticks, or racks, to dry for two or three weeks and then threshed by beating with sticks [17]. This method is tedious and experiments have shown that the European method of stooking, as for corn, can be used with very considerable saving of labour and no appreciable loss of seed [8].

Yield

It is extremely difficult to obtain an average figure for sesame yields in East Africa; or for other producing countries for that matter. Figures given in the literature on the subject vary from as little as 300 lb. to as much as 1,000 lb. of seed per acre. The average yield from native farms in the Southern Province of Tanganyika, where sesame is the major export crop, is probably of the order of 300 to 450 lb. per acre. In the Teso district of Uganda 400 lb. per acre is considered a good yield on native farms.

Storage

On native farms the quantity stored is usually small, in which case it is kept in earthenware jars, or wrapped in small banana leaf parcels sealed with dung and hung above a fireplace. Where large quantities are stored loose in a granary the seed should be removed periodically for sun-drying. In parts of East Africa conical storage receptacles, holding about 1 cwt., are made of mud and grass; the narrow openings of these being sealed with mud to exclude moths. Sometimes larger receptacles are used grouped on platforms, one foot above ground, under a thatched roof [3].

Oil Extraction

Sesame seed usually contains about 50 per cent of edible oil of excellent quality. This oil can be extracted simply, but effectively, by pounding the seed in a wooden mortar, after which the oil is removed by a flotation process with hot water. In India and parts of East Africa a primitive machine known as a Cheka is used. This consists of a large mortar with a heavily-weighted pestle which is slowly revolved by oxen or camels. A charge of about 40 lb. of seed can be extracted with this machine in about two hours [16]. When pressing sesame seed by modern hydraulic machinery special experience is necessary owing to the high oil-content of the seed. A continuous-working expeller gives satisfactory results, provided that the moisture content of the seeds is low, under 5 per cent. In

Europe and Asia it is customary to express the oil in three stages: the first cold and the second and third at higher temperatures and pressures. The cold-pressed oil, which is clear, pale and almost tasteless, is ready for use as edible oil after filtration. The hot-pressed oil, which is dark and with a decided flavour, is usually refined and deodorized before being used for edible purposes [13] [14]. The residual press-cake is a valuable cattle food, its approximate analysis [5] being:—

Moisture	Oil	Protein	Carbohydrates	Fibre	Mineral matter
8%	9	39	25	5	14

Diseases and Pests

In Tanganyika sesame is reported as being singularly free from diseases and insect pests, but in adverse years they may do extensive damage in places [25]. The main diseases of sesame reported in Tanganyika are Leaf Curl, Bacterial Disease (*B. sesami* and *B. solanacearum*), Mildew (*Oidium erysiphoides*) and Leaf Spot (*Cercospora sesami* and *Helminthosporium* sp.) (Wallace *in litt.*). Six species of shield bugs are reported from Uganda. These pierce the fruits and suck the seed, causing serious damage even when only one or two bugs are present per plant. The caterpillar of *Antigastria catalaunalis* is a major pest and widely distributed in Uganda. The gall-forming midge, *Asphondylia sesami* is also an important pest and is capable of reducing yields by 40 per cent [17]. Three leaf-spot diseases are known on sesame in Uganda: *Cercospora sesami, Cylindrosporium* sp. and *Alternaria macrospora*, while the root-disease *Rhizoctonia bataticola* is widely distributed. Sesame is also susceptible to wilt disease, *Verticillium dahliae*, but not to the same extent as cotton [17].

Economics

In considering the economics of sesame production it should be remembered that the yield from this crop is only about one-third that of groundnuts, whereas the price of the product is not correspondingly greater. The cash return to the grower is therefore considerably less than from groundnuts, and must always be so unless the local price of sesame is much higher than groundnuts. It is reported that in the Belgian Congo groundnuts are the more attractive crop for native farmers being easier to grow, higher in yield and easier to store and for these reasons it was anticipated that groundnuts would replace sesame to a large extent in native agriculture, excepting on the less rich soils at higher elevations [20] [26].

In Uganda it is said that the African farmer does not grow sesame on any scale in those areas where groundnuts can be grown equally well, and as cheaply. It is a major crop only on those soils which are so sticky as to make groundnut growing uneconomic owing to high harvesting costs. On such soils low sesame yields may be counterbalanced by low costs. Another advantage of sesame is its low seed rate, a serious consideration in times of scarcity when groundnut seed is likely to be in short supply, whereas sufficient sesame seed is nearly always available.

Unless the plant breeder can solve the problem of excessive loss of crop through the shedding of seed during harvesting operations it is unlikely that sesame would ever be grown in East Africa by European farmers.

It would be greatly to the advantage of East Africa if instead of exporting soil-fertility in the form of whole sesame seed all such seed could be pressed locally so that the rich residual press-cake could be returned to the land by using it as cattle food.

Literature

[1] Ali Mohamed and Zafar Alam (1933).—*Ind. J. Agr. Sc.*, 3, 897.

[2] Allnutt, R. B. (1936).—*E. Afr. Agr. J.*, 1, 369.

[3] Badger, G. D. (1941).—*E. Afr. Agr. J.*, 7, 76.

[4] Bailey, L. H.—*Cyclopedia of American Agriculture*, New York.

[5] Bolton, E. R.—*Oils, Fats and Fatty Foods*, London, 1928.

[6] Burkill, I. H.—*Dict. of Econ. Products of Malay Peninsula*, London, 1935.

[7] Greenway, P. J. (1945).—*E. Afr. Agr. J.*, 10, 254.

[8] Faulkner and Mackie.—*West African Agriculture*, C.U.P., 1933.

[9] Hailey, Lord.—*African Survey*, O.U.P., 1938.

[10] Howard, A.—*Crop Production in India*, O.U.P., 1924.

[11] Hunter and Leake.—*Recent Advances in Agr. Plant Breeding*, London, 1933.

[12] Irvine, F. R.—*A Textbook of W. African Agr.*, London, 1934.

[13] Jamieson, G. S.—*Vegetable Fats and Oils*, New York, 1932.

[14] Lambourne, J. (1922).—*Malayan Agr. J.*, 10, 94.

[15] Macmillan, H. F.—*Tropical Planting and Gardening*, London, 1935.

[16] Milsum and Lambourne (1933).—*Malayan Agr. J.*, 21, 429.

[17] Nye, G. W.—In *Agriculture in Uganda*, O.U.P., 1940.

[18] Sampson, H. C.—*Bull. of Misc. Inform.*, Add. Ser. XII., H.M.S.O., London, 1936.

[19] Simmonds, P. L.—*Tropical Agriculture*, London.

[20] Tihon, L. (1935).—*Bull. Agric. du Congo Belge*, 26, 492.

[21] Watt, G.—*Commercial Products of India*, London.

[22] Wood, R. C.—*A Note-book of Tropical Agriculture*, Trinidad, 1937.

[23] Worthington, E. B.—*Science in Africa*, O.U.P., 1938.

[24] Worthington, E. B.—U.S.D.A. Yearbook of Agriculture, Washington, 1934.

[25] Worthington, E. B.—Pamphlet No. 41, Dept. of Agr., Tanganyika, Dar es Salaam, 1945.

[26] Worthington, E. B. (1928).—*Bull. Agr. du Congo Belge*, 19, 132.

[27] Worthington, E. B.—Monthly Letter, Dept. of Agr., Tanganyika, Annexure 1, Feb., 1933.

(3) SUNFLOWER

(*Helianthus annuus*)

The sunflower, which is not known in the wild state, was in cultivation in pre-Columbian America, its original home being the region between Mexico and Nebraska [4] [6]. It has long been established as an oil seed crop of great economic importance in parts of Europe and Asia, the principal exporting regions before 1939 being Russia, Argentina, the Balkans and China. It is not grown extensively in Africa.

The sunflower is grown mainly for its seeds which yield an excellent edible oil, while the residue left after the extraction of the oil makes a first-rate protein cattle-cake, provided that the seed has first been decorticated, otherwise the fibre content of the cake is too high. The seed-heads, after threshing, can be ground into head-meal in a cob mill and used for feeding cattle and poultry (*vide* analysis below). The crop is also used for green-manuring and is grown extensively for making silage. In Russia sunflower stalks are burned for potash production, the yield being of the order of 160 lb. of ash per acre, yielding 40 to 50 lb. of potash [3].

The following figures show the approximate composition of sunflower seeds, kernels, decorticated cake and head-meal [6]:—

	Fat	Crude Protein	Carbo-hyd-rates	Crude Fibre
Seeds	27%	15%	21%	29%
Kernels ..	45%	27%	16%	3%
Cake (decorti-cated ..	9%	38%	22%	16%
Head-meal* ..	6%	9%	30	

*Containing 5 to 10% of seeds.

Varieties

The best-known varieties in the past have been the giant types with black, white or grey seeds and heads 12 to 22 inches across. These mammoth types, unfortunately, have certain well-known faults. They are very sensitive to wind, they are late in maturing and their large heads are so fleshy that they are difficult to dry. In England, where until recently the sunflower was better known as an ornamental than as a crop plant, considerable interest has been shown in the farming world of late in the newer semi-dwarf varieties 4½ to 7 ft. tall with heads 7 to 9 inches in diameter. These newer varieties, apart from being less prone to wind damage, have the great advantage of maturing early and will ripen in 15 to 17 weeks in Southern England. The best-known of these newer varieties are: Pole Star (grey-striped seed), Southern Cross (striped), Jupiter (black) and Mars (black). Attempts are being made to obtain seed of these varieties for distribution and trial in East Africa. It is not yet known whether these semi-dwarf varieties have any countervailing defects.

Sunflower varieties inter-cross freely so that it is necessary to grow each kind in isolation if the production of pure seed is of importance. If the sunflower is taken up to any extent in East Africa it will be necessary to ensure a pure source of selected seed, otherwise mixing of varieties and deterioration is likely to take place.

Climate and Soil

Although not of tropical origin, the sunflower will thrive at medium and high elevations in the tropics and can usually be grown where maize succeeds. When grown in tropical lowlands the plant usually flowers prematurely, its flower heads being undersized and the seeds few in number. It is an unexacting crop and not particular in its soil requirements and will thrive in ordinary good soil with a warm, sunny and moist climate. It does not do well, however, on acid soils, waterlogged land or steep slopes. It is somewhat hardier than

maize and will grow with a lower rainfall and under a lower standard of soil fertility. It shows a somewhat wider range than maize, however, in its tolerance of both wet and dry conditions. Although the plant is a gross feeder, making heavy demands on the soil, it does not appear to need any special manuring. Highly fertile soils should be avoided, since on these the plants may grow too tall, lodge and ripen late.

Cultivation

Land for sunflowers is usually prepared as for maize. The place of the crop in the rotation will depend largely on the soil, a suggested rotation for use on European farms in South Africa being maize (two years), groundnuts, sunflowers and beans [5].

In the past it has been customary in East and South Africa, when dealing with giant varieties, to sow seed in rows 3 to 3½ ft. apart with the plants 15 to 24 inches apart in the rows. This spacing is too generous for the semi-dwarf varieties, which are commonly sown at the rate of 20 lb. per acre spaced at 18 to 21 inches between the drills with the plants thinned to 12, or even 9 inches in the rows [2]. It is recorded that the closer the rows, within reason, the better the crop, as close spacing produces relatively small heads which dry more readily. Plants with huge prize-winning heads are top-heavy and blow over. Another advantage claimed for close spacing is that the small seeds from small heads, contrary to expectation, have an appreciably higher oil content [2]. For a maximum yield an even and close stand is necessary. If wide spacing is adopted it is advisable to sow an undercrop, such as dwarf beans, to protect the soil and smother weeds.

Sunflower seed needs a fairly fine seed-bed, well consolidated. The seed is sown 1 to 1½ inches deep according to circumstances, either by hand or with a small hand-drill. Alternatively, a maize-planter fitted with special seed plates can be used [8]. Sowing should be timed, if possible, so as to allow the crop to be harvested in the beginning of the dry season after three to four months growth during the rains.

Weeding is necessary during the early stages of growth, but once the crop has established itself, say when 3 ft. high, its growth is so rapid that it tends to smother all weeds so that no further attention is needed till harvest.

Harvesting

This is the most difficult operation with the sunflower crop, for if it is not done at the right time heavy loss of seed may result. The sunflower is different from other crops in that its leaves may still be green when the head is ripe. The surest sign of ripening is the shrivelling and browning of the florets on the face of the flower-head. At the same time the backs of the heads turn from green to a bright yellow. The heads should be cut just before they are fully ripe in order to minimize losses from shedding and birds. Unfortunately the crop does not ripen evenly, but where the area planted is small this can be overcome by harvesting the heads as they ripen. On larger areas the crop should be cut when the majority of heads are ready. In East and South Africa it has been customary to harvest the heads, without the stalk, when the seeds are in the hard-dough stage, but in damp climates the whole plant is cut and cured in stooks, or else stacked on both sides of wires stretched across the field about 3 ft. from the ground. Notable progress has been made in England during the past two years with direct combine harvesting, for which a special technique is being developed. Giant types of sunflower are worthless for this method of harvesting [2]. The following procedure for harvesting by hand is said to give good results in Kenya. The field is first opened up by cutting out lines 30 yards apart for the carts. Working with one man to two rows, the ripe heads are then carefully clipped off with pruning shears, close to the disk, and placed in buckets which are emptied into sacks and left for the carts which follow [6]. A method sometimes used in the U.S.A. is for the reaper to throw the cut heads against the high side of a moving wagon, when much of the seed falls out, the rest being removed by a second man using a curry-comb [6].

Threshing

With small crops this can be done by rubbing the dried heads on a piece of small-mesh expanded-metal nailed to a wooden frame. With larger areas a huller is necessary. Good results can be obtained with an ordinary maize-huller, suitably adjusted. Better results are obtained using a modified maize-huller fitted with a special helice-type drum. After threshing the seed must be thoroughly sun-dried before bagging. The safe moisture content for storage, according to Canadian evidence, is 12 per cent in bulk and 14 per

cent in sacks [3]. A bag of dry seed should weigh approximately 103 lb. gross, or about half the weight of a bag of maize.

Yields

Recorded yields vary enormously. Thus in South Africa a yield of 1,000 lb. of seed per acre is said to be satisfactory [5] [9], while in England yields in 1945 ranged from about 500 to 2,200 lb. per acre. The average yield in Argentina is under 1,100 lb. per acre and the maximum there about 1,800 lb. [1]. In East Africa yields up to 1,500 lb. per acre should be obtainable [6].

Diseases and Pests

Rusts and mildews have been reported as fairly common on sunflowers in Tanganyika (Wallace, G., *in litt*), while on one occasion a serious attack of *Sclerotium* rot (*S. Sclerotiorum*) was reported from one area in N.E. Tanganyika where it destroyed 30 to 40 per cent of the plants [10]. Five fungi attacking sunflowers are reported from Uganda [7]. No serious diseases of the sunflower are recorded from Kenya [6].

The most serious pests attacking the crop are undoubtedly the seed-eating birds. It is claimed that the varieties which cast their heads down while ripening and finally bend over at the neck are less liable to bird damage [11]. Cut-worms may damage the young plants in their early stages but can be controlled by poisoning with paris green mixed with chopped grass.

One advantage of the sunflower as a crop for East Africa is that it is not readily eaten by locusts as long as more palatable food is available [4].

Economics, Etc.

Although there is still a lot more to be learnt about this crop in East Africa there is no doubt that it is a possible alternative crop for certain parts of the country. Whether sunflower seed will ever be a profitable export crop must depend on world prices and the relative yield and cost of production in East Africa as compared with other producing countries. No cost of production figures are available for sunflowers in East Africa, but in South Africa it is reported that there the cost is practically the same as for maize [5]. A few hundred tons of sunflower seed were exported from Kenya during 1933-37 when prices were high, but exports ceased as soon as prices fell again. Interest is being shown in sunflowers in the Southern Highlands of Tanganyika, where it is expected that several hundred acres will be sown in the Iringa district this year by European and African farmers.

The present acute world shortage of edible oils is likely to continue for some considerable time, suggesting that there may be a keen demand for any edible oil-seeds which East Africa can produce for export, including sunflower seed. Now that oil-expelling plants have been erected in East Africa there is a possible opening for a small local market in sunflower-oil and cattle-cake. Apart from any idea of growing for export or for the local manufacture of oil and cake, there is a place for the sunflower on every mixed farm where it will grow, as a provider of valuable stock and poultry food as well as a source of nectar and wax for bees.

As regards native agriculture, it is possible that the African might be interested in sunflowers as a cash-crop at prices lower than those which would be acceptable to the European farmer in East Africa. The crop also has distinct possibilities as a provider of much-needed oil and protein in native diet. Even if the African only developed the catching habit of chewing sunflower seeds for pleasure during odd moments of the day, as most of the peasants of Central Europe seem to do, he would augment his food intake appreciably.

Literature

[1] Blackman, G. E. (1944).—"Sunflowers as an Oil Seed Crop", *J. Min. of Agr.*, 50, 11, 517.

[2] Blackman, G. E. (1946).—"Sunflowers as an Oil Seed Crop", *J. Min. of Agr.*, 53, 1, 27.

[3] Bolton, E. R.—*Oils, Fats and Fatty Foods*, London, 1928.

[4] Cockerell, T. D. A. (1937).—In Bailey's *Standard Cyclopaedia of Hort.*, New York, 1937.

[5] du Toit, F. M. (1934).—"Sunflower as a Field Crop", *Farming in S. Africa*, 9, 314.

[6] Elmer, L. A. (1938).—"The Sunflower", *E. Afr. Agr. J.*, 4, 218.

[7] Hansford, G. G. (1943).—*E. Afr. Agr. J.*, 9, 55.

[8] Jamieson, G. S.—*Vegetable Fats and Oils*, New York, 1932.

[9] Leppan and Bosman.—*Field Crops in S. Africa*. Cent. News Agency, S. Africa, 1923.

[10] Wallace, Maud (1944).—*E. Afr. Agr. J.*, 9, 171.

[11] Wallace, Maud (1946).—*Hort. Abstracts*, 14, 1.

THE HOME ORCHARD

By T. H. Jackson, Dip. Hortic. (Reading), Department of Agriculture, Kenya.

(*Received for publication on 1st December*, 1946)

Deciduous Fruits, Soft Drinks and Nuts

Although fruit growing has been recorded as one of man's agricultural activities from the earliest times, in the Highlands of East Africa deciduous fruits were unknown before the advent of European settlers. Many settlers have planted fruit trees and this requires courage in a country where fruit growing has not previously been attempted. It is these pioneers who have made possible the writing of this article. The state of our knowledge on deciduous fruit growing in East Africa is still very incomplete, but it is now possible to make some definite recommendations for the guidance of new growers and for the assistance of those who are already growing fruit.

The object of this article is to supply information, particularly of a local nature, to those who wish to plant a small orchard, mainly to suppy fruit for home consumption, but also with a view to selling any surplus produce on the local market. The prospective grower who wishes to grow fruit commercially, although he will obtain much useful information from the following pages, will have to go much deeper into the problems of fruit growing than is possible here.

The home orchard should provide fruit for as long a period as possible during the year. Early, mid-season and late varieties of each kind of fruit should be chosen when possible. Those varieties which will keep well are particularly desirable. It is important to choose kinds and varieties which are suited to local climatic conditions. The prospective grower should visit the orchards of his neighbours, note which kinds and varieties are doing well and make his own selection from amongst these.

In East Africa temperature is the biggest factor affecting the growth of deciduous fruits. The mean temperature, apart from local variations, decreases as height above sea level increases. Altitude, therefore, is a convenient way of indicating in what climates different kinds of fruit are likely to be successful. The growing of deciduous fruits is confined to the higher altitudes, with climates which can be described as almost temperate.

There are no definite seasons in East Africa as we know them in Europe. This lack of a summer and winter is an important factor with deciduous fruits, which require a dormant season for their successful growth. At the higher altitudes fruit trees do go dormant, usually in July and August, but the dormancy is often incomplete. The degree of dormancy is to a large extent varietal, and this factor has been utilized by the plant breeder to produce varieties suited to climatic conditions which are not quite temperate or even sub-tropical.

Trees which are not happy in their environment suffer from what is known as "delayed foliation" or "prolonged dormancy". This condition is brought about by high temperatures in the dormant season, or in the case of varieties bred for sub-tropical climates, by temperatures which are generally too low for the particular variety. "Prolonged dormancy" is characterized by a reluctance on the part of the tree to come to life again after the dormant period. Individual branches or shoots will remain in a dormant state while other parts of the tree are in flower or leaf. Later, fruit, flowers and leaves may be seen on the tree at the same time. The prolonged flowering period results in a poor set of fruit, and the small number of leaves which are open at any one time is often insufficient to mature the crop. It follows that in a year when mean temperatures during the dormant season are abnormally high a poor crop of fruit is harvested during the following growing season.

In other deciduous fruit growing countries with climates similar to those of the highlands of East Africa, it has been found that the application of an oil spray during the dormant season is of great assistance in breaking the dormant period. In South Africa increases in yields of fruit of up to 500 per cent have been recorded as the result of winter oil spraying. In East Africa oil sprays have not been tried extensively, but results, so far, are encouraging. Growers who wish to try the effect of an oil spray for themselves should proceed as follows:—

To make stock emulsion: 1 gallon raw linseed oil, 3 gallons water, 2 lb. soft soap. Heat the water almost to boiling and add the soap, stirring until it is all dissolved. Add the linseed oil, little by little, agitating vigorously with a stick or pumping through a garden

syringe. It is essential that all the oil be thoroughly emulsified with the soap and water. To one gallon of the stock emulsion add four gallons of water. The spray is now ready for use. It should be applied in the middle of the dormant season, and all parts of the trees should be covered.

The diurnal range of temperature is very great throughout the Highlands, and its effects on the growth of deciduous fruit is not yet fully understood. It is, however, responsible for physiological cracking in fruit, especially of apples and apricots. The intensity of physiological fruit cracking is varietal, and it is so bad on some varieties as to make them not worth growing. Rainfall varies greatly from district to district, but all parts of the country where deciduous fruit is grown are more or less dry from the middle of December to the beginning of April. It is unfortunate that during this period all deciduous fruits are maturing their crops, a time at which a good supply of water is necessary if the fruits are to grow to the correct size. Hail storms are quite common in certain districts and can do great damage to fruit trees and fruit crops.

Kinds and Varieties of Fruit to Plant

The following is a list of kinds and varieties of fruit with the approximate ranges of altitudes at which they have been found to grow most successfully. There are brief cultural notes on each kind of fruit.

The author is well aware that examples of fruits being successfully grown outside the altitude range recommended for any particular kind or variety in the following list are by no means uncommon. In many cases the evidence that a certain kind can be grown successfully in a certain area is not sufficiently conclusive to warrant a definite recommendation. When in doubt growers are advised to consult the Department of Agriculture on varieties of fruit to plant in any particular locality.

Almonds

Almonds generally do well from 7,500 to 8,500 feet. The following are good varieties: Britz, IXL, Paper Shell, Non Pareil, Drake's Seedling. Nearly all varieties of almonds are self-incompatible and require to be pollinated by other varieties if they are to bear well. The following varieties will cross pollinate and should be planted together: Drake's Seedling, Nonpareil, IXL. Paper Shell is said be a good pollinator of other varieties. Almonds are among the first of the deciduous fruits to come into flower; as the weather at this time is usually cold it is advisable to have bee hives in an almond orchard so that the bees can take advantage of short sunny periods to pollinate the flowers without having to fly long distances.

The trees should be planted at 25 ft. x 25 ft. spacing. Young trees should be trained to a vase shape; pruning of older trees consists in thinning out the oldest shoots each year in order to allow the production of vigorous new fruiting wood. In some districts bird scarers are necessary during the flowering period.

Apples

Some varieties can be grown at an altitude of around 7,000 ft., but most varieties are happier at between 8,000 to 9,000 ft. Many orchards have been more or less successful owing to the use of "Northern Spy" as a root-stock. The prospective grower who is going around looking at his neighbour's trees may think, after seeing apple trees on "Northern Spy" stock, that apples are a failure in his district. He should always ask to see trees grafted on Crab or "Cape Seedling" stock; these will give a much better idea of the possibilities for apple growing.

Very many varieties have been tried locally, but owing to lack of space it is not possible to describe them all here. The following are a few of the most successful varieties:—

The letters C and D denote varieties suitable for cooking and dessert.

Ballarat Seedling.—(C) 8,000–9,000 ft; of Australian origin; a good keeper; late.

Blenheim Orange.—(D) 7,000–9,000 ft.; an old English variety; good keeper; a vigorous grower; mid-season.

Christmas.—(D) 8,000–9,000 ft.; heavy cropper and a very pretty dark red apple, but its appearance is superior to its flavour; will not keep; early.

Cleopatra.—(D) 7,000–9,000 ft.; of Australian origin; keeps well; mid-season.

Gravenstein.—(C) or (D) 8,000–9,000 ft.; of German origin; a vigorous grower; mid-season.

Jonathan.—(D) 7,000–9,000 ft.; of American origin; good keeper; mid-season.

King of Tomkin's Country.—(C) or (D) 7,000–9,000 ft.; of American origin; vigorous grower, but inclined to bear fruit on the tips of its shoots; good keeper; late.

Ohenimini.—(D) Of New Zealand origin; although a vigorous grower and a good cropper this variety is not recommended owing to its susceptibility to physiological cracking of the fruit.

Reinette de Canada.—(C) 7,000–9,000 ft.; a very old variety; keeps well; late.

Rome Beauty.—(C) or (D) 7,000–9,000 ft.; upright growth; good keeper; mid-season.

Sharp's Early.—(D) 8,000–9,000 ft.; will not keep; a good early apple.

Syke House Russet.—(D) 8,000–9,000 ft.; excellent flavour and keeps well; late.

Springdale.—(C) or (D) 8,000–9,000 ft.; of Australian origin; late.

Versfeld.—(C) or (D) 7,000–9,000 ft.; a South African variety; good keeper; mid-season to late.

Laxton's Superb.—(D) 8,000–9,000 ft.; an English variety; late.

White Winter Pearmain.—(C) or (D) 8,000–9,000 ft.; very old English variety; keeps well; late.

The planting distance for apples is 20 ft. to 24 ft.

Some varieties are self-incompatible and others, although classed as compatible, set better crops if cross pollinated by another variety. Local information as to time of flowering of different varieties is lacking, and it is advisable to plant several varieties together.

Trees should be pruned as follows:—In the middle of the growing season all vegetative shoots, except the leaders or terminal shoots, should be broken in half. The top half should be left hanging. The effect is to encourage the formation of fruit buds in the lower part of the shoot by restricting sap flow. During the dormant season cut back midway between the break and the base of the shoot. The leaders should be cut back to half the previous season's growth at the same time.

Some varieties, such as King of Tomkin's Country, have a tendency to bear the majority of their fruit and leaves towards the tops of the branches. Growth can be forced out on the bare lower parts of the branches by tying them down in a horizontal position. On no account must the tips of the branches be below the horizontal. The bark under the tie takes considerable pressure, and must be protected by a pad of sacking.

Apricots

The apricot is best grown at 8,000–9,000 ft., but occasionally it may be seen doing well at somewhat lower altitudes. The fruits are very subject to physiological cracking. Gumming of the trees is liable to occur on badly drained soils. Pruning of mature trees is similar to that for almonds. In cases where mature trees continue to make an excess of vegetative growth when they should have settled down into bearing, Summer pruning as described for apples should be resorted to. The trees need water when the crop is maturing; good crops cannot be expected if sufficient soil moisture is lacking at this time. The following varieties are recommended:—

Early Cape.—Early.

Royal.—Mid-season.

Blenheim.—Mid-season.

Tilton.—Late; culinary.

The planting distance for apricots is 20ft. to 25 ft.

Berries

Ra-strawberry.—Up to 9,000 ft.; white-stemmed raspberry erroneously known as "Himalayan Blackberry; planting distance 6ft. x 2 ft.

Loganberry.—Makes poor growth and bears only light crops; will not grow below 7,000 ft.

Raspberry.—7,000–9,000 ft.; Lloyd George is the best variety.

The best way to grow raspberries is to plant them in rows 2 ft. between plants and 6 ft. between rows. The growth of suckers, which is copious, should be restricted to a width of 2 ft. in each row; any suckers arising outside this area should be removed by frequent hoeing of the soil. Old canes should be cut out after they have borne a crop. For those not wishing to take all this trouble, lighter crops will be produced by allowing the canes to grow as a thicket.

Black, Red and White Currant.—The climate is unsuitable for currants.

Gooseberry.—The gooseberry is unsuited to the climate.

Cape Gooseberry has become a weed in many districts, but it is worth a place in the orchard; it is excellent stewed or made into jam. Planting distance 4 ft. x 2ft.

Strawberry.—5,500–8,000 ft. One of the best varieties to grow is Melba, of Australian

origin. It is a non-running variety and is propagated by division. It has the great advantage of being practically immune to leafspot (*Mycosphaerella fragariae*), which is such a scourge of most of the varieties grown. Strawberries should be planted 2 ft. x 1ft. Replanting is necessary as from six months at the lower range of altitude to two years at the top of the range.

Alpine Strawberry.—7,000—9,000 ft. Bears heavy crops of small fruit, of good flavour.

All berry fruits require heavy manuring (up to 50 tons of farmyard manure per acre) and ample supplies of water if the best results are to be obtained. Good drainage is essential.

Cherries

8,000–9,000 ft. Cherries are not extensively grown in Kenya. Crops are apt to be very irregular. Several varieties should be planted together for cross-pollination. The following varieties are recommended; White Heart, Monstrueuse de Mezel, Bigarreau Twyford. Planting distance 20 ft.

Figs

5,000–8,000 ft. For dessert purposes the so-called self-fertile varieties should be grown; the following are recommended: —

Castle Kennedy.—Old English variety; excellent for dessert.

Negro Largo.—Fruit large black; no use for drying.

White Genoa.—Excellent eating and a good drying variety.

White Ischia.—Good; medium sized fruit.

The above varieties will all produce fruit for dessert purposes without pollination. If dried figs are required it is necessary that the flowers should be pollinated by the insect *blastophaga* which makes its home in the Capri fig. It is essential therefore, if fruits suitable for drying are required, to plant the Capri fig in proximity to other varieties. A good supply of soil moisture is necessary when the crop is maturing, otherwise the fruit is liable to drop before maturity or to be lacking in juice when ripe. Propagation of figs is by cuttings or suckers. Planting distance 20 ft. Apart from shaping young trees very little pruning is necessary.

Nectarines

Nectarines do not appear to be well suited to our climate. A few growers have been moderately successful at altitudes between 8,000–9,000 feet. The variety recommended is Goldmine.

Peaches

The peach can be grown from 5,000–8,500 ft., but the best results are obtained between 6,000–8;000 ft. Many varieties are grown locally, the following are some of the best:—

Angel.—5,000–8,000 ft.; early; white flesh; freestone.

Alexanther Jewel.—5,000–8,000 ft.; early; creamy white flesh.

Babcock.—A comparatively new variety which has been bred for sub-tropical conditions; white flesh, freestone; dark red cheek; late.

Killicrankie.—5,000–8,000 ft.; early; flesh white; freestone.

Mamie Ross.—8,000–8,500 ft.; late; flesh white; half clingstone.

Muir.—7,500–8,500 ft.; late; suitable for drying; flesh yellow; freestone.

Pallas.—7,500–8,500 ft.; mid-season; freestone; white flesh.

Shackleford.—5,000–8,000 ft.; early; white flesh; freestone.

Hall's Yellow.—6,000–8,000 ft.; yellow flesh; suitable for canning.

Planting distance 20 ft. to 25 ft.

The growing of peaches from seed is not to be recommended as they do not come true to type. Annual pruning of peach trees is esential; if neglected the crop will gradually diminish in size until little or no fruit is borne. Pruning consists of thinning out and shortening back the older wood. Always cut to an outside shoot when shortening branches. Thinning of the fruit when small is necessary to prevent over-bearing and for the production of large fruit. Thin the fruit to not less than six inches apart.

Olives

The trees grow quite well at the higher altitudes, but do not bear fruit.

Chestnuts

8,000–9,000 ft. The trees grow and bear quite well, but the nuts are inclined to be small. Planting distance 30 ft.

Pecan Nut

The pecan is now becoming more popular than the walnut. It has not been grown much

locally, and most of the trees that have been planted are growing under unfavourable conditions. Pecans require a well drained soil not less than 10 ft. deep. Ample soil moisture is essential from flowering until the nuts mature. River banks with deep soil and the water level about 6 ft. from the top of the bank are suitable.

From 5,000 to 8,000 ft. would probably be the best range of altitude. Different varieties are suited to different climates, but little is known at present about the relation of varieties to local climates.

Several varieties should be grown together for cross-pollination. The following varieties are recommended for trial: Curtis, Schley, Moneymaker, H. L. H. Stuart.

The planting distance is 60 ft.

Mulberry

4,000 ft. upwards. The kind most usually seen in Kenya is probably *Morus japonica.* There is another, however, which has fruits up to six inches long, which grows from the coast up to 6,000 ft. The name is unknown. Mulberries are easily propagated by cuttings. In order to obtain large fruit the trees should be pollarded to about 4 ft. every other year and well supplied with water when the crop is maturing. It is as well to plant enough to supply the birds as well as yourself. Planting distance 20 ft.

Pears

The pear is probably better adapted to our climatic conditions than the apple. There are sub-tropical varieties which do well from 7,000 ft. upwards, while the French pears can be successfully grown at the higher altitudes. It is advisable to plant several varieties together for cross-pollination. Planting distance 20 ft.

The following varieties are recommended:—

Keiffer.—7,000–9,000 ft.; mid-season to late. This variety is tolerant of sub-tropical conditions and will succeed where all others will fail. Very vigorous grower; suitable for dessert, cooking or canning; keeps well.

Le Conte.—7,000–9,000 ft.; mid-season; heavy bearer; will not keep. Should be planted as a pollinator for Keiffer.

Packham's Triumph.—7,000–9,000 ft.; mid-season to late; a fairly vigorous grower and bears well; good keeper.

Smith's Hybrid.—7,000–9,000 ft.; mid-season to late; vigorous grower; Keiffer type.

Fertility.—8,000–9,000 ft.; very heavy bearer; mid-season; will not keep; a good pollinating variety.

Jargonelle.—8,000–9,000 ft.; early; vigorous grower; will not keep.

William's Bon Chretien.—8,000–9,000 ft.; the most popular of pears; mid-season; excellent for dessert, canning or drying; keeps fairly well.

Hessle.—8,000–9,000 ft.; early; the trees have a spreading habit of growth; will not keep.

Duchesse d'Angoulême.—8,000–9,000 ft.; mid-season to late; keep well; a good dessert variety.

Winter Nelis.—8,000–9,000 ft.; mid-season; a good dessert variety and keeper; will pollinate William's Bon Chretien.

Laxton's Superb.—8,000–9,000 ft.; resembles William's but ripens a little earlier; not a good keeper.

Many varieties take some years to come into bearing. Trees may be brought into bearing considerably earlier by tying down the branches in a horizontal position as described for apples. This operation should not be carried out before the trees are 6–7 ft. high. Summer pruning, as for the apple, is also helpful with trees reluctant to come into bearing.

Pears are usually pruned to a vase shape; inside and crossing branches should be cut out. The annual growth should be shortened back in the dormant season. With varieties that tend to over-bear it is advisable to thin the fruit buds during the winter pruning. The right time at which to harvest pears is always a difficult problem for the amateur. Most varieties may be picked when the seeds begin to turn brown. With William's the fruit should be lifted to the horizontal, if the stem breaks the fruit is ready for picking. Most pears require house ripening after picking. The above tests are an indication of picking maturity only.

Plums

Most of the Japanese plums are well suited to our climatic conditions, and on the whole will succeed with less attention than apples, pears and peaches. It is important to choose varieties suited to the climate in which they are to be grown. Several varieties should be planted, for cross-pollination and to extend the season. Planting distance 20 ft. to 25 ft.

The following is a list of selected varieties:—

Beckie Smith.—7,000–8,000 ft.; large red fruit; late.

El Dorado.—8,000–9,000 ft.; very large, almost black when ripe; late.

Hale.—7,000–9,000 ft.; extremely vigorous and bears well; medium size; yellow fruit; late.

Methley.—7,000–9,000 ft.; fairly vigorous and a very heavy cropper; fruit, dark red, of medium to small size; a good variety for jam making; early.

Jardine's Early.—7,000–9,000 ft.; vigorous and a good cropper; fruit red, of medium size.

Purple King.—7,000–9,000 ft.; fruit dark crimson and of large size; late.

Santa Rosa.—7,000–9,000 ft.; one of the most popular dessert varieties; large fruit of dark crimson colour; mid-season.

Satsuma.—7,000–9,000 ft.; a good variety for dessert and canning; dark red fruit of large size; late.

Tagazine.—7,000–9,000 ft.; vigorous grower and heavy bearer; fruit dark red of medium size; early.

Settler.—7,000–9,000 ft.; a local variety, similar to Methley but somewhat larger; early.

Wickson.—7,000–8,000 ft.; a good dessert variety; fruit red with yellow flesh, of large size; must be pollinated by Satsuma.

Watson's Cropper.—7,000–9,000 ft.; very vigorous; a red plum of medium size which crops heavily; mid-season.

Wilson.—7,000–9,000 ft.; small red cherry plum of very sweet flavour; early.

The branches of plum trees must be thinned regularly otherwise the growth becomes much too dense. Many varieties tend to overbear and thinning of the branches helps to reduce the crop to reasonable proportions and increase the size of the fruit. When the crop is heavy the branches should be propped to prevent breakages.

Quinces

The altitude range is from 7,000–9,000 ft., but quinces will grow and crop better in the upper half of the range. Suitable varieties are as follows: Meeches Prolific, Orange Quince, Rae's Mammoth, Portugal. Branches will require thinning at intervals to prevent the growth becoming too dense. Planting distance 15 ft. Propagation by cuttings.

Walnuts

Little is known about the culture of walnuts in Kenya; they have been grown successfully on a small scale at altitudes of around 9,000 ft.

Walnuts are very subject to delayed foliation in Kenya. Some varieties are more tolerant of warm winter conditions than others, and it is these varieties, some of which are named below, which are most likely to succeed here; Blackmer, Placentia Prolific, Payne.

The trees should be spaced at 60 feet apart. In California early bearing varieties such as Payne may start bearing worth-while crops at five years from planting; other varieties may take seven to eight years. Trees do not come into full bearing until they are twelve to sixteen years from planting. The Japanese walnut (*Juglans sieboldiana*) has also been grown locally; its nuts are of little use, but possibly it is worth growing as an ornamental.

Orchard Management

Rootstocks

With apples, and to a lesser extent pears, the type of rootstock used has a fundamental effect on the subsequent growth of the tree and may make all the difference between success and failure of the tree as a fruit producer. Many of the apple trees which have been planted in this country are grafted on "Northern Spy" rootstock. "Northern Spy" is a rootstock which is much used in South Africa; one of the main reasons for its popularity is that its roots are immune to attacks of the Woolly Aphis (*Eriosoma lanigerum*). We now know that "Northern Spy" is an unsatisfactory rootstock for apples under our local climatic conditions; it produces a dwarfish tree which lacks vigour. Immunity to Woolly Aphis is no longer very important as it has been proved that this pest can be controlled by means of parasites. There are two other rootstocks in fairly general use locally for apples, they are "Cape Seedlings" and "Crab"; both produce vigorous trees and it is recommended that growers ordering trees from nurserymen should specify one or other of these stocks.

Pears are usually grafted on "Wild Pear" or quince, of the two "Wild Pear" is generally the best stock to choose as quince is apt to be too dwarfing in its effect under local conditions. Many other rootstocks have not yet been tried locally, and it is hoped that this

will be the subject of future investigational work by the Department of Agriculture.

Another line which requires investigation is the growing of fruit trees on their own roots; that is, from cuttings or layers. Trees grown from cuttings have been seen in several local orchards; they appear vigorous and are reported to bear good crops. Growers might be interested to try growing trees from cuttings for themselves, but it must be pointed out that many varieties do not root easily from cuttings. The practice is not recommended for general use until a comparative trial has been carried out.

Purchasing Fruit Trees

When purchasing fruit trees always buy the best, they will certainly be the cheapest in the end. If a nurseryman offers more than one size of tree choose the largest. Large trees are always easier to establish in the orchard and will grow away much faster than small ones. If, through lack of choice, small trees have to be purchased it is better to plant them in nursery rows at 4 ft. by 2 ft. for a year, where they can be watered and generally cared for, than to plant them out at orchard spacing straight away. The extra transplanting which the trees thus receive is of great benefit to their root systems. Always choose proved varieties rather than novelties. It is the novelties which the nurseryman splashes across the coloured pages of his catalogue, because he can ask a higher price for them than for the old favourites. The illustrations are often very attractive and one is often strongly tempted, but it should be remembered that these new varieties very often disappear after a year or two and are not heard of again. The above remarks do not apply to local nurserymen.

Choosing an Orchard Site

The choice of an orchard site is a matter which requires careful consideration. It should be borne in mind that the economic life of an orchard is from 25 to 50 years, depending on the kinds of fruit planted in it. It will be seen, therefore, that if a mistake is made at the outset there is plenty of time for regrets afterwards. The first thing to consider is the aspect; a western aspect is usually best as it will give protection from the prevailing wind. Fruit trees cannot be grown successfully if exposed to a gale. If a protected aspect is not available it is necessary to plant tree windbreaks, and have them properly grown before any fruit trees are planted. Even a protected aspect will probably require tree windbreaks, but in this case they may be planted at the same time as the fruit trees.

An examination of the soil should next be carried out. Fruit trees require a depth of at least 4 ft. of well drained soil. A series of holes should be dug at intervals, to a depth of 4 ft. If rock or hard murram is found at a depth of less than 4 ft. the site is unsuitable. Heavy clay, particularly near the surface, should also be avoided. If in doubt, directions for taking soil samples should be obtained from the Soil Chemist, Department of Agriculture, and samples forwarded to him for his examination and report. Provided that the aspect is right, the depth of soil is adequate and drainage is good, an orchard site should not be abandoned because it is found that the soil is lacking in certain plant foods. Such deficiencies can be remedied by proper manuring.

The orchard should be sited as close as possible to the homestead in order to discourage thieving. If the site contains trees which will have to be removed to make way for the fruit trees, they should be ring-barked and allowed to die before being uprooted. On old forest land there may be tree stumps remaining, these must be carefully removed, together with as many of their roots as possible.

The fungus *Armillaria mellea* will attack and kill fruit trees; much damage has been caused by it in local orchards. This fungus is often present in old tree-stumps, and from their roots will spread to the fruit trees. Ring-barking trees and allowing them to die before felling sometimes has the effect of rendering their roots unsuitable hosts for the fungus.

Fences and Hedges

It is essential to erect a buck-proof fence round the orchard before planting the trees. Small buck and even hares will do great damage to young fruit trees; in some cases the trees are ring-barked and killed. A buck-proof fence can be made by interlacing bamboo in an ordinary 3-strand wire fence. Every orchard should be surrounded by a thorny hedge to discourage thieving. At high altitudes *Pyracantha Angustifolia* is recommended, at lower altitudes *Lycium Horridum* is suitable. Put in the plants 1 ft. apart in a single row. The hedge will make more rapid growth if before planting a trench, 2 ft. deep and 18 in. wide is dug and manured, on the

line where the hedge is to be. It is a mistake to interlace plants with the idea of making the hedge grow thicker. The effect of interlacing is to slow down the growth. To thicken a hedge cut back the new growth to about half its length at intervals of a few months. Hedges should always be trimmed to a narrower width at the top than at the bottom; this will present the bottom branches from dying out. Hedges should not be closer than 25 ft. to the nearest fruit tree.

Orchard Lay-out

Most books on fruit growing, with the exception of recent publications, recommend that fruit trees should be planted on the square system, and great emphasis is laid on having the trees in straight lines. This is not the best modern practice. It has been found in America and South Africa that soil and water conservation, and the practice of irrigation, are all made much easier if the tree rows follow the contour of the land. Growers who wish to plant orchards on the contour are advised to have the lay-out done for them by the Soil Conservation Service of the Department of Agriculture.

When planning the orchard, a section should be allocated for each kind of fruit. This will facilitate cross-pollination and reduce the labour required for such operations as harvesting and spraying. Different varieties of the same kind of fruit should be planted in alternate rows to encourage cross-pollination. A plan should be made of the orchard showing the position of each tree and its name. Tree labels are very apt to get lost or destroyed and no reliance should be placed on them as a means of identification.

Preparation for Planting

The land should be double ploughed and harrowed, or dug deeply with a fork. Any small depressions or mounds should be graded off before the tree rows are laid out. A hole should be dug for each tree, 3 ft. in diameter and 3 ft. deep. The top soil should be thrown on the higher side of the hole and the sub-soil on the lower side. The holes should be left open for as long as possible in order to allow the sub-soil in the sides and bottoms to be weathered. Holes should be filled two to three months before planting, so that the soil may settle. Holes should be filled entirely with top soil, to which may be added a cigarette tin of meat meal to each hole. The remaining sub-soil should be scattered on the surface between the holes. Pegs must be replaced to mark tree planting positions. The soil should be levelled for a radius of 3 ft. from each peg, and a bank 6 in. high built up on the lower side in order to form a basin to catch rainwater. This basin must be maintained after planting.

If the slope of the land is at all steep a line of New Zealand spinach or perennial pea should be planted between each row of pegs, at the onset of the rains. These wash stops will be in addition to the contour terraces, which will have been laid out and dug at the same time as the tree holes.

Planting

The only time to plant deciduous fruit trees is when they are dormant. Dormancy usually occurs in the months of July and August. In many districts this is the period of heaviest rainfall, but in others little rain can be expected during these months. If the soil is dry, a four-gallon tin of water should be poured into each planting hole on the day previous to planting. After planting it will be necessary to water the trees until sufficient rain falls. The 6 ft. diameter basin which surrounds each tree should be flooded to a depth of 2 in. every two weeks. At each planting peg a hole must be opened sufficiently large to accommodate the roots of the tree to be planted in it without bending or crowding them. It is important that the tree should be planted at the same depth at which it stood in the nursery; the soil mark can always easily been seen on the stem. Great care must be taken to protect the roots of young trees from drying out before planting by keeping them wrapped in wet bags. Broken or damaged roots should be cut back to sound wood and long straggling roots should be shortened. A piece of 2 in. x 1 in. timber with a notch cut in the centre should be laid across the hole, with the notch over the centre of the hole. The stem of the tree is placed in the notch at the height of the soil mark and held there. The roots should now be spread carefully in the hole with the other hand. Soil should now be filled in slowly by another operator while the first presses it firmly round the roots until the hole is filled.

It protection from wind is inadequate, the trees should be staked as soon as planted. A stake, which need not be more than 2 ft. long above the ground, should be inserted about 9 in. from the stem of each tree and on the windward side. The tree should be attached

to the stake with stout twine. The bark must be protected by a pad of sacking where the tie would come into contact with it.

Cultivation

From the time it is planted the orchard should be clean cultivated. It is not possible to grow fruit trees successfully in grass. For the first few years vegetables, strawberries and other soft fruits may be grown between the tree rows, but great care must be taken to ensure that tree roots are not damaged when cultivating the interplanted crops. Cultivation should only be undertaken if there is a definite need for it, that is to remove the weeds or to aerate the soil and increase its capacity to absorb water. There is an idea still prevalent that the land should be cultivated, when possible, after every shower of rain, with the object of forming a dust mulch on the surface. The dust mulch is supposed to retard evaporation of water from the soil, but in fact it does not do so. Weeds will compete seriously with fruit trees for water when at the end of the rains the soil moisture is beginning to get scarce. At this period they should be removed without delay by shallow cultivation. During the rains there should be plenty of water for all and weeds may be left to assist in preventing soil wash. Deep cultivation, that is to a depth of 6 in., should not be necessary more than once a year; it should preferably be done when the trees are dormant, and on no account must it be done between the times of flowering and harvesting. When cultivation is done, tree basins and contour terraces should be built up to the correct size where necessary.

Irrigation

All fruit in Kenya would probably be better grown under irrigation. Where water is available for this purpose it should certainly be utilized. Careless use of water, however, can do great damage both to the trees and to the soil. It is not possible to enter here into the details of irrigation practice, but the following are the most important points to be remembered:—

1. Irrigate all the dry soil within the root zone, i.e. to a depth of 4 ft. with mature trees.
2. Do not irrigate a wet or moist soil.
3. Do not irrigate with brackish water.
4. The irrigation layout must be arranged so that loss of soil is negligible.

Usually the basin system of irrigation is best. A furrow is run midway between each row of trees. All the land between the furrows is divided into basins which are flooded in turn with water from the furrows. For mature trees the basins should be flooded 4 in. deep about every four weeks when the soil is dry, and the trees are flowering or cropping, and in need of water. It is difficult properly to irrigate orchards unless the layout has been designed with that purpose in view. It is advisable, therefore, when laying out an orchard to allow for irrigation in the future, even if water is not available at the time the orchard is started.

Pruning

In the section "Kinds and Varieties of Fruit to Plant" the pruning of mature trees of specific fruits has already been dealt with. It is necessary now to deal with pruning of young trees and certain general principles of pruning.

It is often recommended that young trees should be cut back to knee height and to a single stem after planting. This system may be used on small trees, that is, unbranched or maiden trees. It is recommended that where possible larger trees should be planted; in this case it is probable that the formation of the branch framework has already been started, and to cut such trees back to knee height would be merely to set them back in their growth one or two years. Large trees should not be pruned after planting, except on expert advice. Starting from an unbranched tree which has been cut back to knee height, three or four branches should be selected from those which will grow from the main stem. The branches should arise, if possible, not less than 9 in. from ground level and should be spaced up the main stem, not shooting out all at one point. Any unwanted shoots should be rubbed off when they are small. If, as often happens with peaches, plums and almonds, the selected shoots reach a length of more than 3 ft. before the next dormant season, the terminal bud of each should be removed with the finger and thumb in order to force out shoots lower down. Cut back a third to half the season's growth in the dormant season. The next stage is to produce two shoots on each of the three to four main branches, which will give the tree six to eight secondary branches. From these secondaries two shoots are again produced which will give twelve to sixteen tertiary branches. This is the main framework of the tree on which fruiting spurs or laterals are borne. It is not always possible in practice to

be quite so mathematical about the number of framework branches, but the above should serve as a guide.

A point requiring frequent attention is the removal of suckers from the main stem. All growths which arise below the main branches should be removed as they appear. Many of them will start from the rootstock below the graft union, and if allowed to remain will grow faster than the rest of the tree, eventually swamping it altogether. The owner will be left with a rootstock. When, for any reason, it is necessary to remove a branch, it should be sawn off flush, on no account should a snag be left. Snags will die back and provide a means of entry for disease. The bark round the edge of the wound should be pared smooth with a knife to facilitate healing. All wounds of an inch or more in diameter must be protected with a dressing. Ordinary white lead paint, which is often recommended for this purpose, is of no use as it invariably cracks after a time and diseased spores can enter through the cracks. The best wound dressings are bituminous compounds such as "Shelmac", which is obtainable from the Shell Oil Co. Bituminous compounds always remain elastic and are not subject to cracking. On no account should coal tar be used, as it has a lethal effect on the wood cells. When pruning always cut to an outside bud or shoot; the cut should slope away from the bud. In the dormant season all dead wood should be cut out as a routine measure.

The following tools are the most suitable for pruning fruit trees:—The knife: the best type is that with a hooked blade. Secateurs: the "Rolcut" type is recommended. Saws: a frame saw should be used, or a piece of bandsaw blade round one end of which a piece of sacking may be wrapped as a handle. The curved pruning saw is not recommended as it is often difficult to start a cut at the correct angle with such a wide blade.

Manuring

Cattle manure should be applied annually at the rate of a bag per tree for mature trees, and half a bag for young trees. Agricultural lime or ground limestone should be applied at the rate of 5–15 lb. per tree every other year. It is dangerous to apply lime only and to neglect the cattle manure. The effect would be to use up the plant foods in the soil much faster than would otherwise be the case. Lime should not be applied at the same time as cattle manure.

If possible the manure should be applied just before the annual deep cultivation, which will effectively bury it. It is also desirable that the manure should be applied just before rain is expected. In some districts and seasons it may not be possible to combine the deep cultivation with the advent of rain. On no account should manure be left lying about on the surface where the sun will destroy much of its value. Manure should be broadcast on the surface and immediately afterwards incorporated with the surface soil by cultivation. Do not bury manure in trenches or pits in the orchard; the best method of application is broadcasting.

Thinning of Fruit

With some kinds of fruit thinning is necessary in order to produce fruit of reasonable size and to keep the trees in regular bearing, with other kinds it is less necessary but advisable. The peach probably needs more thinning than any other deciduous fruit. If left unthinned a large crop of small fruit will be produced; in the next season a very small crop will probably result, followed by a heavy crop in the next season. The life of the trees will also be shortened. To produce fruit of good size and to keep the trees in regular bearing for their life of approximately 25 years, peaches should be thinned to about 6 in. apart. The fruit should be thinned before the kernels harden. Cropping of plums is usually kept within reasonable limits by restricting the number of bearing branches per tree. This is a more economical method than thinning the fruits. Pears may have their crops reduced by cutting down the number of fruiting buds per fruit spur during dormant season pruning. Thinning of the fruit will be necessary if very heavy crops are set. Apples do not usually set very heavy crops in East Africa, but where four or five fruits are set from a single bunch of blossom it is advisable to remove two or three of them if quality fruit is required.

Bees

For proper pollination of the flowers an adequate bee population is necessary at flowering time. One hive of bees per acre of fruit trees should be sufficient. Those who do not like keeping bees themselves should encourage natives to hang their beehives round the orchard. The weather is often cold and overcast at flowering time, a fact which does not encourage activity in bees. If, therefore, hives are placed in or near the orchard the

bees can take immediate advantage of short sunny periods to pollinate the flowers without having to fly long distances to do so.

"Passenger" Trees

It is usual to find that a percentage of the trees planted in an orchard, generally about 5 per cent, are stunted, miserable and generally unsatisfactory. Such trees can usually be identified about two years after planting, and they should be removed and replaced with healthy trees. The cause of such behaviour can usually be traced to a bad graft union or an off-type rootstock. Another type of "passenger" is the variety unsuited to the climate in which it is growing. Provided the trees are healthy they should be top-worked or grafted with another variety which is doing well in the orchard. The advice of the Department of Agriculture should be sought on methods of top-working fruit trees.

Windbreaks

The necessity for windbreaks has already been emphasized. Species of Cypress have proved the most successful locally; *Cupressus macrocarpa, C. torulosa* and *C. lusitanica* are all suitable, but it is advisable to consult the local office of the Forest Department as to the best species to plant in any particular district. Windbreaks should not be planted closer than 40 ft. to the nearest fruit trees. In order to prevent their roots encroaching on the orchard a trench should be dug 18 in. wide and 4 ft. deep at a distance of 10 ft. from the windbreak and parallel with it throughout its length. The influence of a windbreak extends to about ten times its height. Additional windbreaks, therefore, will be required at intervals if the orchard is a large one.

Picking, Packing and Storage

Great care must be exercised in picking fruit; small abrasions will cause rotting in storage. Fruit should not be thrown from the tree into a box. Canvas bags or canvas bottomed buckets are suitable picking receptacles and may be suspended from the neck or hooked to the top of a ladder. When picking, the fruit should be gripped in the palm of the hand and not by the finger tips; this particularly applies to peaches. Peaches should be carefully placed in a single layer in boxes cushioned with wood wool as soon as picked. The home grower is not much concerned with packing fruit for market, but occasionally he may wish to dispose of a surplus. It is not possible here to enter into details with regard to packing fruit, but the following general principles will serve as a guide:—It is essential to grade fruit for size before packing, if this is not done a good pack is impossible. Only new, clean boxes of sound construction should be used for packing fruit. The fruit must be packed tight enough so that they will not shift in the box if it is shaken. Pack the fruit in layers and in diagonal lines in the boxes.

If any quantity of fruit is to be stored with the object of supplying the household for as long a period as possible after harvesting it is advisable to build a semi-underground fruit store. A site should be chosen on sloping ground, to provide drainage, and heavily shaded by trees. The ground should be excavated to the height of the walls at the higher end of the slope. The walls should be stone and the floor of concrete. A thick thatched roof is required to keep the temperature even. The roof must be netted beneath with 1½ inch wire netting to keep out rats. The soil excavated should be banked up against the walls at the lower end of the slope. Top and bottom ventilators should be provided; they should be closed during the day and opened at night. The fruit should be stored on slatted racks with no fruit touching another. If space is restricted fruit will have to be stored in boxes, but losses from storage rots will be increased. If possible each fruit should be wrapped in paper.

PESTS

Few fruit growers realize how lucky they are in East Africa in not having to combat some of the worst pests and diseases of Europe and other part of the world. Routine spraying several times a year are the rule in most fruit growing countries if a crop is to be produced. There is no telling how long it will be before these pests are imported into East Africa. Local residents can help to delay the evil day by helping to enforce the present regulations governing the importation of plants and fruits into this country.

Birds.—Probably the worst pests of deciduous fruit here are birds. An orchard with large trees in the vicinity will suffer most. The most effective way of controlling birds is a man with a gun in the orchard at fruiting time. Bird lime is helpful and coffee banding grease can be used for this purpose. It should be smeared on sticks which should be balanced

in the fruit trees. Poisoning of partly eaten fruits will kill large numbers of birds, but other members of the local fauna will also suffer if due care is not exercised.

Moles.—They are very fond of the roots of fruit trees, and often cause a tree to die or fall over. Traps should be set as soon as their earths are seen in the orchard.

White Ants.—Most damage is done at the lower altitudes. A nest near a tree will cause serious drying out of the roots. They also destroy manure and other organic matter in the soil. All nests should be dug out.

Buck and Hares.—The necessity for protecting young trees from these animals has already been emphasized.

Leaf-eating Beetles.—Serious damage is often done to the leaves of young trees by these pests. In appearance they are small, black or brownish beetles, $\frac{3}{8}$–$\frac{1}{2}$ in. long. They feed mostly at night and during the day are to be found hiding in rubbish or the surface soil. They may be controlled as follows:—Tie a loose fold of sacking round the trunk of each tree a few inches from ground level. The beetles will hide in the sacking during the day. The sacking should be removed once weekly and the beetles shaken out into a bucket containing water and a little paraffin.

Borers.—The damage is done by the larvæ of probably more than one species. Plums, peaches and figs suffer most. These pests cause considerable damage in some districts, while in others they are hardly ever seen. The larvæ bore large holes in the wood of fruit trees, often travelling considerable distances in the tree. The presence of a borer is indicated by frass exuding from a small hole in the bark, or at a later stage by the collapse of a branch. A careful watch should be kept for frass. A wire may be pushed into the hole and the larva impaled on it.

Fruit Flies.—Of the deciduous fruits most damage is done to peaches, but other kinds are also liable to attack. The adult fly, about the size of an ordinary house fly, but more brightly coloured, lays its eggs under the skin of the fruit shortly before the fruit is due to ripen. Larvæ hatch from the eggs and feed on the interior of the fruit. Pupation takes place in the soil. The whole life cycle is completed in a few weeks. The following measures should be taken to control the pest:—

(1) *Orchard Sanitation.*—All fallen fruit should be collected daily and buried not less than 2 ft. deep. The object is to destroy the larvæ before they pupate in the soil.

(2) *Poison Baiting.*—All fruit trees should have two patches of leaves, one on each side of the tree, sprayed with fruit fly bait once weekly. The spray should fall on the leaves in large drops. As the spray is very poisonous the fruit should not be sprayed. The adult flies are attracted by the bait and die after feeding on it. Both controls are useless unless carried out to a strict timetable.

Fruit fly bait should be made as follows: lead arsenate $1\frac{1}{2}$ oz., white sugar $2\frac{1}{2}$ lb., water four gallons. The arsenic will settle out if the mixture is not constantly stirred. The following is an alternative recipe: sodium fluosilicate 1 oz., white sugar 2 lb., water four gallons.

False Codlin Moth.—This is often confused with fruit fly, the damage to the fruit being similar, but the larvæ can be distinguished by the fact that the False Codlin Moth larva has legs while the Fruit Fly larva has not. The percentage of fruits attacked seldom exceeds 5 per cent. Control by orchard sanitation as for Fruit Fly, but poison baiting is not effective.

Fruit Sucking Moths.—Will attack most deciduous fruits. The moths feed at night, puncturing the fruit and sucking out the juice. Damage to the fruit is similar in appearance to that done by fruit flies; a small puncture can usually be seen in the centre of the affected area. Some control can be effected by placing lamps in basins of water in the orchard at night. A reflector on top of the lamp will help to deflect the moths into the water. A film of oil should cover the surface of the water.

Woolly Aphis.—A serious pest of the apple. It is a sucking insect which infests both the roots and the branches of the trees. The insect induces the formation of characteristic galls on the branches. It is easy to identify woolly aphis by its cottony exudations of white wax. Control is by means of parasites and by grafting trees on rootstocks which are resistant to attack.

Diseases

Crown Gall.—The disease attacks peaches mostly, but it will also attack other kinds of fruit. The disease appears as rough, corky galls on the trunk at or just below ground level. It has a debilitating effect on the tree and in advanced stages may cause death. The disease is bacterial and will infect the soil, which in turn will infect healthy trees which are planted in it. The disease cannot be cured, but may be kept in check by cutting out the

galls with a chisel and protecting wounds with a wound dressing. Infected nursery stock often introduces crown gall into an orchard, but in East Africa it is quite probable that the disease is spread from indigenous trees also. Galls removed from a tree should be burnt and the tools sterilized after use. An infected tree should not be used for propagation.

Peach Leaf Curl.—A serious disease of the peach. The leaves are distorted and often have a pinkish colour, later they die and turn black. Twigs are also infected, and these can be recognized by their stunted and thickened appearance. All infected wood should be removed and burnt. Infected leaves which fall from the tree should also be swept up and burnt. In orchards where the disease is bad the trees should be sprayed with lime sulphur, or with Bordeaux mixture at a strength of one per cent. The spray should be applied at the end of the dormant season just before the buds begin to swell.

Shot Hole Fungus.—The apricot is the most susceptible fruit, although other kinds may be affected. The leaves develop small holes. May be controlled by spraying with Bordeaux mixture at a strength of 1 per cent.

Apple Mildew.—Certain varieties, such as King of Tomkin's Country, are susceptible. Infection is usually mostly on the young shoots, which have a silvery appearance. Control by cutting off infected shoots or spraying with lime sulphur or dusting with sulphur.

Apple and Pear Scab.—In East Africa this disease is not usually sufficiently serious to warrant spraying, but bad attacks have been noted. The disease is characterized by brownish or black rounded scabs on the fruits of apples and pears. The disease also attacks the leaves and wood of the tree. In Europe the disease is controlled by spraying with lime sulphur or Bordeaux. Three applications are necessary. Growers are advised to consult the Department of Agriculture before spraying for this disease. Diseased fruits should not be left lying about in the orchard, and where the leaves have been badly attacked they should be swept up and burnt. Diseased wood should be cut out at pruning time.

Lichen and Semi-parasitic Plants.—These are not really diseases, but can be conveniently dealt with under that heading. Lichens will attack all fruit trees and if not controlled have a debilitating effect. The trees should be sprayed in the dormant season with a mixture of water and caustic soda at the rate of 1 lb. of caustic soda to ten gallons of water. Various semi-parasitic plants such as Loranthus make fruit trees their hosts; their effect on the trees is harmful and the growths should be cut out whenever seen.

Vines

The grape vine in East Africa may sometimes be seen growing in rather unexpected situations with apparent success. For example there is a large vine, which must be well over 20 years old, growing over a morgue in Mombasa; it is reported to bear large crops every year, but it receives ample supplies of water and manure.

In general, the climatic requirements of the vine are low temperatures in winter and high temperatures with only moderate rainfall in summer. Altitudes ranging from 6,000 ft. to 7,500 ft. are usually the best for vine culture, but, as stated, exceptions do occur. The site chosen for planting must be well drained and not too sheltered from wind. Valley bottoms are usually unsuitable.

When preparing land for planting, the soil should be cultivated as deeply as possible; if a sub-soiler is available the land should be sub-soiled in both directions. The most suitable spacing for the plants is 8 ft. between rows and 10 ft. apart in the rows. The rows should run approximately parallel with the direction of the prevailing wind, as this will discourage disease by giving adequate ventilation.

The trellis on which the vines are to be supported may be erected after planting. The "T" trellis is the most suitable, and may be made by planting posts, which should project 4 ft. above the ground, at 30 ft. intervals in each row. A cross-piece 2 ft. long is fixed to the top of every post at right angles to the line of the row. A wire is strained at a height of 2 ft. from the ground between the posts and is supported by droppers at 10 ft. intervals. Two more wires are strained, one at each extremity of the cross-pieces, so that they run parallel with each other.

Pruning is carried out when the vines are dormant, and in the first year after planting should aim at forming the permanent framework of the plant. This consists of a single stem which branches into two just below the lower wire. The two branches are extended parallel to the ground by tying them to the lower wire, and should be cut to a length of 5 ft., when they will meet with the corresponding branch of the next vine in the row. There should be no overlapping between the

horizontal branches of adjoining plants. From the horizontal branches growths will be produced which will develop into the vine's permanent fruiting spurs. The spurs should be spaced at about 9 in. apart on the horizontal branches. Every year the annual growth from the spurs is cut back, in the dormant season, to within two buds of its base (short pruning), except in the case of varieties which require long pruning which are cut back to within six to eight buds of the base. The type of pruning required is indicated in the list of varieties by the letters "S" or "L". The annual growths on which the fruit is borne are tied to the two upper wires of the trellis. There the plant is trained in the form of a V, which allows proper penetration of sun and air.

Any suckers arising from the main stem should be removed. It is usual to top the annual growth during the growing season; the tops may be removed at five to six leaves above the top bunch on any lateral or annual growth. For production of high quality bunches it is necessary to thin the berries; this is done by cutting out, with scissors, all inside and crowded berries. The bunch will appear very thin after this operation, which should be done when the berries are the size of a small pea. Vines are gross feeders and require plenty of manure; an application of about 40 lb. of cattle manure or compost per vine should be made annually during the dormant season. Lime at the rate of 1–2 lb. per vine may be applied in every other year; it should not be applied at the same time as the cattle manure. As many of the vine feeding roots are near the surface deep cultivation is not advisable. The operation known as "envelope forking" may be resorted to in the dormant season to aerate the soil and to increase penetration of rainwater.

The vine is very susceptible to various diseases—notably Powdery Mildew (*Oidium*) and Anthracnose. Control of these diseases is absolutely essential if crops are to be produced. It is not possible here to give full descriptions of the symptoms of these diseases. Briefly, Anthracnose appears as dark greyish spots sometimes surrounded by a ring of brown or yellow on the leaves, stems and berries. The results are premature leaf fall, interference with sap flow, death of berries and serious reduction of crop. Powdery mildew appears as white, powdery, irregular spots and patches on leaves, stems and fruit. The results are the same as for Anthracnose except that the whole crop may be destroyed.

The control for Anthracnose is dormant season swabbing or spraying of all parts of the vines, after pruning, with one of the following solutions:—A 4 per cent solution of sulphuric acid and water; or 1 lb. copper sulphate dissolved in two gallons of water; or lime sulphur at a strength of 1:8 with water. The dormant season treatment must be followed by three applications of sulphur dust to the leaves during the growing season. The first application should be made when the shoots are about six inches long and the remaining applications should follow at monthly intervals. Sulphur dusting, as for Anthracnose, will also control powdery mildew, but the dormant season treatment is not necessary for this disease.

Vines are easily propagated by cuttings, but owing to the presence of the insect *Phylloxera* in most vine-growing countries it is necessary to graft the required varieties on to roots of one of the American stocks, which are resistant to attacks by *Phylloxera*. *Phylloxera* has not yet been reported in East Africa, but it will probably appear sooner or later. It is safer therefore to plant only vines which have been grafted on to resistant roots.

The following is a list of varieties which have been successfully grown in East Africa:—

Muscat Hambro.—(S) early; purple.

Red Muscatel.—(S) early; red; berries and bunches small.

Crystal.—(L) mid-season; white.

Red Harefoot.—(L) mid-season; red.

Gros Colman.—(S) late; black.

Alphonse Laralle.—Late; black.

REFERENCES

[1] Bailley, L. H.—Cyclopaedia of Horticulture (1935).
[2] Esselen, D. J.—Citrus Irrigation Practices, *Science Bulletin No.* 159, Union of South Africa.
[3] Davis, R. A.—Fruit-growing in South Africa 1928.
[4] Jackson, T. H.—The Stumping and Treatment of Wounds of Coffee, *Coffee Board Bulletin* (1938).
[5] Ministry of Agriculture and Fisheries, Collected Leaflets, Fungus Diseases of Fruit Trees.
[6] Chandler, W. H.—Deciduous Orchards (1942).
[7] Wickson, E.—California Fruits.
[8] Gardening in East Africa, 1st and 2nd Editions.
[9] "Powdery Mildew or Oidium—Diseases of the Vine" by Dr. S. J. du Plessis, *Farming in South Africa* (October, 1944).
[10] "Anthracnose of the Vine" by Dr. S. J. du Plessis, *Farming in South Africa* (March, 1940).
[11] "The Training and Pruning of Grape Vines" by E. M. Nyenhuis, *Department of Agriculture and Forestry, Pretoria*; *Press Service No.* 803 *of 4th September*, 1945.

NOTES ON ANIMAL DISEASES

II—EAST COAST FEVER AND RELATED DISEASES*

Compiled by the Department of Veterinary Services, Kenya Colony

East Coast Fever

East coast fever is a disease of cattle caused by the small protozoan parasite *Theileria parva*. The multiplying stages of this parasite, "Koch's blue bodies", are found in one of the types of white cells (lymphocytes) in the spleen, lymph glands, kidneys and other organs. These stages are occasionally found in the lymphocytes in the blood. The red cells of the blood usually contain other stages of the parasite, known as small piroplasms.

East coast fever received its name from the fact that the disease was first recognized in cattle introduced into Rhodesia through Beira in 1901.

Methods of Infection.—East coast fever is non-contagious. In nature the disease is always transmitted by the bites of infective ticks. Experimentally it can be reproduced by the inoculation of spleen pulp and blood taken from an animal reacting to the disease.

Incubation Period.—The incubation period varies from six to twenty-five days, the average period being about thirteen days. The duration of illness is from six to twenty days (usually about eight days) from the first rise in temperature. Under ranching conditions animals may be noticed to be sick only two or three days prior to death. In cases which end fatally death usually occurs from twenty to twenty-five days after exposure to the bites of infected ticks.

Symptoms.—Apart from the rise is temperature, early symptoms are not very marked. The animal may be somewhat listless and tend to lag behind the herd. As the animal continues to feed until the disease is well advanced the illness may pass unnoticed by the native herdsman. The most characteristic symptom is swelling of the lymphatic glands; the superficial glands beneath the ears, in the hollow in front of the shoulder and in the fold of the skin in front of the stifle become prominent. In the later stages œdema of the lungs causes a marked disturbance in respiration. Finally the animal becomes weak, lies down and rises with difficulty or not at all.

Cattle suffering from east coast fever frequently relapse to redwater, and in such cases the symptoms of the latter disease are superimposed on those of the former.

In a certain percentage of cases the eyes are affected. A whitish film appears on the surface of the eyeball and blindness results. In cases which recover, the animal regains its sight.

Mortality in adult animals introduced from "clean" areas to highly infected areas may reach 95 per cent. When outbreaks occur in clean areas, however, a high percentage of recoveries is sometimes reported. Such outbreaks may appear so unusual that the true nature of the disease is not suspected. The animals are sick for a few days only, enlargement of the glands is not marked, and may pass unnoticed; in fact, careful examination may reveal that only one superficial gland is slightly swollen. In such cases small piroplasms may be rare in the blood and Koch's bodies may be concentrated in one lymphatic gland. Prolonged searching of a routine gland smear may fail to establish the presence of parasites, although the appearance of the cells in the smear may suggest that the case is one of east coast fever.

Post-mortem Lesions.—In cases from an enzootic area a diagnosis can often be made from the appearance of the organs after death. It is necessary to stress, however, that in sporadic cases from clean areas the classical lesions are often absent.

In typical cases the lungs are markedly œdematous and hyperæmic. When incised, a frothy, yellowish fluid exudes from the cut surface. Froth may be found in the windpipe and at the nose. When the lungs are thus affected some yellow fluid is usually present in the chest cavity. The heart may show hæmorrhages under the membrane lining the left ventricle.

The fourth stomach is frequently congested and discrete ulcers, usually black in colour and angular in shape, may be present. The intestines may be congested and may show scattered hæmorrhages. Lines of hæmorrhages are often present in the rectum. Lesions in the intestines are often lacking in calves.

The liver is usually enlarged, and mottled and pale in colour. The gall-bladder is usually distended with thick bile. When a breakdown to redwater has occurred the liver is often yellow or orange in colour and, of course,

* Being a revision of the article on this subject which appeared in this Journal in March, 1939.—*Editor.*

lesions of that disease may be present in other organs.

The spleen may be slightly enlarged, but is not markedly thickened or greatly increased in size unless the case is complicated with redwater.

In typical cases, in adult cattle from highly infected areas, the kidneys show "infarcts", reddish or pale yellowish-white spots varying in size from that of a pinhead to that of a small pea. When near the surface these "infarcts" are seen projecting slightly from the surface of the kidney after the capsule of the kidney has been stripped. Typical "infarcts" are rarely seen in cases from clean areas.

The lymphatic glands are swollen and on section the cut surface is very moist; indeed an excess of fluid usually escapes.

Transmission.—The most important transmitter of east coast fever is the brown tick, *Rhipicephalus appendiculatus.* The black-pitted tick, *R. simus,* the Cape brown tick, *R. capensis, R. neavei,* and the red-legged tick, *R. evertsi,* were shown experimentally to be capable of transmitting infection during the early years of the century and until recently it was thought that transmission was restricted to species of this genus. In 1937, however, Fotheringham and Lewis showed at Kabete that certain species of *Hyalomma* could also carry infection.

Infection does not pass through the egg of the tick. Larvæ become infected through feeding on an infected animal and after moulting the nymphæ are infective. Similarly nymphæ may pick up infection to transfer to a new animal as adults. If infected nymphæ feed on an immune animal or an insusceptible species, the infection is lost and the moulted adults are clean.

Although a number of different species of ticks are known to be capable of transmitting east coast fever under laboratory conditions, experience has shown that under natural conditions the brown tick is of far greater importance than the others. About 1911 the Colony of Kenya was divided into the present "clean" and "dirty" areas, and it is now realized that the "clean" areas are, on the whole, areas in which the brown tick does not thrive. Isolated islands where conditions for this tick are more favourable occur in the "clean" areas, and in such islands the control of east coast fever is always more difficult.

A point of importance in the transmission of east coast fever is the fact that an infected adult tick can transmit the disease only after it has fed on a beast for a period of not less than 60 hours. An infected tick removed or accidentally detached during the first five days after commencing to feed, should it become attached to another host, is still capable of producing the disease.

Animals Susceptible.—East coast fever is a disease of cattle only. All attempts to infect other domesticated and game animals have failed. At Kabete several attempts have been made to infect buffalo. On the last occasion (1931) a buffalo calf about one month old, caught in a "clean" area, was infected heavily on the ears with ticks of a batch the infectivity of which had been proved. No temperature reaction ensued, nor did daily examination of blood and gland smears reveal the presence of parasites. Later the calf was placed in a highly infected camp for two days. After removal the calf was kept under observation but neither clinical examinations nor smears gave evidence of infection having occurred.

Although animals other than cattle cannot develop east coast fever, it is possible, though unlikely, that they may play a minor role in the spread of the disease. There is always the risk that infective ticks, either unfed or that have not fed for more than five days, may be brushed off immune cattle, game or even off natives' blankets to complete their meal on a new host.

Immunity.—East coast fever is almost unique among protozoan diseases in that the majority of adult animals that recover from a natural attack of the disease develop a strong and durable immunity. When, exceptionally, a second infection is contracted the reaction is not so severe. In calves, it is probable that a considerable percentage are liable to undergo a second, milder infection, and it has been suggested that young calves in enzootic areas suffer from repeated, almost continuous attacks of the disease for a period of several weeks.

The fact that animals born and reared in enzootic areas have a strong immunity, together with the fact that such animals are incapable of infecting ticks, has made possible the use of "T" cattle in Kenya. Cattle from enzootic areas are exposed for six weeks in a heavily infected testing *boma.* Those that survive are branded "T" or "LT", and such cattle are permitted to move between clean and east coast fever infected areas.

Treatment.—No substance of plant origin nor any chemical preparation has been found effective in the treatment of east coast fever. The search for a cure is being continued, the vast majority of new chemo-therapeutic preparations being tested in one or other of the veterinary laboratories in Africa.

Preventive Measures.—The only way of controlling east coast fever is by controlling the transmitting ticks. At one time it appeared as if Mr. J. Walker, O.B.E., late Chief Veterinary Research Officer at Kabete, might have succeeded in elaborating a practical method of provoking an active immunity by the intravenous, subcutaneous and intradermal inoculation of spleen pulp and blood collected from an affected animal. Unfortunately, the method, when tested on a large scale, proved unreliable. A certain percentage of susceptible cattle always failed to react to the injection and later succumbed when exposed to infected ticks. Another variable percentage reacted severely and died. The method, therefore, had to be abandoned.

Fencing, combined with dipping and hand-dressing, is therefore the only satisfactory means of combating the disease available. While dipping and hand-dressing alone can be used to control ticks, fencing renders their application more effective and more complete, and, in addition tends to prevent the introduction of east coast fever and, of course, the introduction of other infectious diseases.

While fencing necessitates a heavy capital outlay, it is the general experience in Kenya that this outlay is repaid by improvement in the condition of the cattle and in the pasture that results when the cattle are left out all night in paddocks.

Dipping in an arsenical fluid should be combined with thorough hand-dressing of the ears, eyelids, brush of the tail, prepuce of males, etc., parts to which the dipping fluid cannot readily gain access. Hand-dressing is of great importance in the control of east coast fever, because the brown tick shows a marked preference for feeding in the ears, on the face and in the brush of the tail. Hand-dressing consists of clipping the long hairs and applying by hand either an oily dressing or the usual dipping fluid. One of the most satisfactory dressings is a mixture of one part of 7 per cent nicotine extract and eight parts of crude oil. Old oil from the sump of a motor car may be used.

As the brown tick usually remains on the host for about four days during the larval stage, four to six days during the nymphal stage, and up to eight days during the adult stage, dipping and hand-dressing every three days should theoretically be the ideal method of controlling east coast fever. In practice, however, dipping every five days in a seven-day-strength dip combined with hand-dressing has proved at least equally effective. In South Africa the latter system is usually employed, although an extra hand-dressing is frequently interpolated in the five-day period.

On farms where previously no measures have been taken to reduce tick infestation it must not be thought that by the rigorous application of control measures a severe outbreak can be checked in a very short time. In practice, even under the best conditions, dipping and hand-dressing will not ensure that every tick is killed before it has fed for 60 hours, and a considerable number of losses may be experienced before the disease is brought under control. On farms where measures to control ticks are in force and tick-life has been reduced to a minimum, outbreaks of east coast fever can never develop serious proportions. Herein lies the value of cattle cleansing.

Cases of east coast fever may occur up to fifteen months after the last case. The difficulty that arises in practice is to determine when the last case has occurred. It is recognized that when infecting ticks become scarce cases may be atypical. Such cases have already been mentioned as being not infrequent during the course of outbreaks in clean areas. It is easy to see how such cases, occurring on a farm during the regulation 18-month quarantine period, may go undiagnosed and yet lead to the maintenance of infection in ticks. Failure to diagnose the continuance of infection may also, of course, be due to failure of an owner to submit slides, or to the submission of slides unsuitable for diagnosis; for example, slides from a decomposed carcass.

The advent of the synthetic insecticides opens up wider possibilities for the application of dipping in the fight against tick-borne diseases. In the past one of the factors which hindered universal dipping in the native areas, especially with herds owned by nomadic tribes, was the necessity to dip at relatively short intervals if one was to obtain any permanent benefit from the procedure. With the greater residual effect left on the bodies of animals dipped in these synthetic products it is possible, if not probable, that it will be practical to lengthen the interval between

dippings, with at the same time better protection against infestation, and thus overcome a very real obstacle.

It must be emphasized, however, that dipping tanks will still be needed for the efficient and easy application of the insecticide, and as far as one can foresee the time when tanks can be dispensed with is not yet in sight.

Turning Sickness

In cattle immune to east coast fever, there occurs on occasion, in certain areas, a condition in which parasites indistinguishable from Koch's blue bodies are found in the brain. This condition is known as "turning sickness" or by its Wakamba name, *Muthioko*.

Occurrence and Etiology.—Turning sickness has only been observed in areas in which east coast fever infection is very heavy.

All attempts to reproduce this condition experimentally have so far been unsuccessful, and it is not known whether the parasite found in the brain is identical with that of east coast fever, or whether it is a closely related species. The fact that engorged nymphæ, collected at death from a case of turning sickness and fed as adults on a susceptible animal, have on occasion induced an attack of east coast fever suggests that the parasite responsible is *Theileria parva*.

Symptoms.—Symptoms of turning sickness may appear in animals that have recently recovered from east coast fever or they may develop many years after an animal has passed through an attack of that disease.

The symptoms consist of walking in a circle, either to the right or to the left, or of giddiness. Eventually paralysis usually occurs. Cases may be acute, death occurring within a few days of the animal being noticed sick, or chronic, the animal appearing to recover from the original nervous symptoms but gradually losing condition. In oxen loss of condition is rendered more rapid by working. Chronic cases have been known to live for over a year.

Post-mortem Lesions.—Definite lesions after death are restricted to the brain and its membranes. In acute cases fresh hæmorrhages and clots are found overlying various parts of the brain or in the ventricles. On occasion clots are found in both localities. The blood vessels of the membranes surrounding the brain are engorged with blood and small hæmorrhages may be discernible in the brain substance.

In chronic cases lesions are not so noticeable. Usually, however, small areas in the brain, that differ from the surrounding tissue by appearing dry or yellowish, may be discoverable.

Diagnosis.—In order to establish a diagnosis of turning sickness, smears are made from the blood clots on the brain or from parts of the brain substance that show hæmorrhages. Such smears should show the presence of Koch's bodies. In this condition it is most unusual to find these bodies in gland or spleen smears. The blood may show the presence of rare small piroplasms.

Treatment.—No method of treating turning sickness has been developed.

Small Piroplasms

Small piroplasms are one of the commonest parasites observed in the routine examination of blood smears in East Africa. They have already been mentioned as one of the forms of the parasite of east coast fever. However, a second species of small piroplasm, known as *Theileria mutans*, exists. This parasite, transmitted by the red-legged tick, is rarely of pathological significance. Almost all undipped cattle become infected early in life, and thereafter harbour the organism in a manner analogous to that in which redwater and anaplasmosis are carried. When a carrier animal contracts a serious disease *Theileria mutans* often reappears in numbers in the blood.

The two species of small piroplasms, *Theileria parva* and *T. mutans*, can rarely be distinguished by the microscopical examination of blood smears. During infections with the latter parasite, however, it is unusual to find Koch's bodies in the glands or spleen, hence the necessity for submitting gland or spleen smears for the diagnosis of east coast fever.

Occasionally when a heavy infection with *Theileria mutans* has also been present, Koch's bodies have been found in the glands of calves dying from paratyphoid. Similarly, when susceptible adult cattle are exposed to a heavy infection with ticks carrying *T. mutans*, a percentage may show Koch's bodies in gland smears during the temperature reaction. All such cases are, however, so rare that the presence of Koch's bodies in gland or spleen smears must be accepted as evidence justifying at least a provisional diagnosis of east coast fever.

ON WRITING FOR THIS JOURNAL

By R. E. Moreau, Assistant Editor, 1935-1944

It is perhaps appropriate that after nearly ten years' close association with the editorship of this Journal I should, on my departure, record some of the ideas that have guided me and some of the things that it has taught me. I do not write from an altogether one-sided point of view, because I have had a good deal of my own writing published in scientific journals. There is nothing new in any of my cautions or recommendations, but it is certain that they need repeating. On some points I am pernickety: you are at liberty to ascribe the strength of my prejudices to "senile obstinacy that seems like mellow wisdom to its possessor".

This journal publishes a wide range of material. At one extreme are the directly advisory articles, such as how to make fences and how to avoid spoiling hides. At the other there are, for example, classified lists of pests and diseases, collections of facts that no one tries to read, but among which technical men will from time to time find, with a whoop of joy, some fact which fits into their problem. Between the two extremes we have had every gradation from the popular to the scientific appeal; inevitably the treatment the authors need to give them differs, but certain principles govern them all.

Unless he is a master of prose an author is making his job more difficult by using long sentences. Too many of them go lame and trail pitifully along with a succession of relative clauses. Another common cause of weakness in such sentences is to state a fact and proceed "so . . ." something or other happens. This kind of writing will not stand the test of being read aloud, which I advocate later in this article. The remedy is simple: cut the sentences up and do not forget that the colon and the semi-colon were invented to help us. Even if an author can manage long sentences well they are better avoided both in popular articles and in strictly scientific exposition. They are out of favour with people who imagine that they are busier than their grandfathers were; and most of us do.

In advisory and semi-popular articles the writing must above all things be clear and readable; and a tendency to repetition is permissible, if it is needed to drive a point home. But such writing need not be dull, nor depend upon a limited vocabulary. I think authors are unduly scared of mild colloquialisms. Humour is too rare; and when inserted it is often over-emphasized by that horrid sign, the exclamation mark: as crude as a jab in the ribs with a pipe-stem.

It ought to go without saying that articles of this kind should use very few technical terms. Some will be unavoidable, and some will come naturally to a professional author as handy abbreviations, but will be strange to many readers. Such a word—for example, "oligophagous"—should be explained the first time it appears in an article. But there can be no excuse for loading an advisory article with professional jargon that can be avoided. A farmer who is exhorted to "maintain his cattle on a high plane of nutrition" may take the trouble to make the necessary translation; or he may not. If he does, and if he acts on the advice, he will feed his cattle well.

From time to time we have given under the heading "Write simply", examples of how obscurely and pompously some people can write. I have just come upon a notable addition to the collection. "The primary consideration is the acquisition of knowledge concerning the standardization of the potentialities of this apparatus." No one I have consulted can suggest, any better than I can, how potentialities can be standardized; but I suppose the gifted author to mean no more than this: "the first thing is to find out exactly what the apparatus can do".

Articles are often too long-winded: sometimes because the author has no power of selection; sometimes because he takes his work so seriously that he cannot bear to leave out anything he thought or did in connexion with it. Another cause, which happily does not operate in East Africa, is that a technical man may be valued by the quantity of his outpourings.

An article can be appreciably swollen by minor flatulencies, such as the following, all of which I found in a half column of print:—

> "When inquiries were instituted it was stated that action would be taken to publish the agreement . . ." "Instances can be multiplied *ad infinitum*." "The association could not see its way clear to accepting help". "Success followed closely on the heels of anti-malarial work."

A strange windy style full of clichés, and reminiscent of that in which they "beg to thank you for your esteemed favour".

Many of the contributions we publish are strictly scientific. None of these can appeal to more than a small proportion of our readers, but we print them for that proportion, which is largely composed of technical men. Moreover, the standard scientific journals would find difficulty in accommodating information which has special local application. But the reason anything is written is to get it read, and the more people who can be persuaded to read it the more the author is rewarded for his trouble. If a man has written on the physiology of the coffee-bush he is sure to be read by plant physiologists and by technical men who are concerned with coffee. But there is another potential public, numerically much greater, consisting of those who grow coffee and perhaps even including those who handle the product. The attention of such readers can be caught and held only if the author realizes that a fog of unexplained technicalities is the opposite of a cloud of glory. No language can be more vivid and arresting than plain English, in which abstract nouns, the abstract construction and words of classical derivation are used when needed, but never for their own sakes.

I believe that the more scientific type of article can be given a wider appeal, without lowering its professional standard. In the first place scientific investigation, like any voyage of exploration and a few detective stories, is exciting. There is no reason why the narrative of it should not be more exciting than it often is. At the start the author should state his problem clearly, what is known about it already, and why he set to work on it. He must then describe his material, his difficulties and his methods in just so much detail as will enable his scientific peers to detect flaws if they exist, or to provide them with ideas and inspiration if the work described justifies it. For the layman, the details included must be confined to those which build up the necessary background and those which are significant in the final discussion. The observations made, or the results secured from experiments, should then be described so that they can be "understanded of the people". From these results the final discussion should be built up; and at this stage no new facts nor other material should be introduced, except comparisons with other work. All the clues should have been put before the reader in the earlier part of the paper; he should have been given an opportunity to construct his own hypotheses and draw his own deductions.

The summary, which so many people find difficult, is worth taking some trouble over, because busy men may look no further and the abstracting journals may quote it word for word. That means that the author wrote his own notice and has only himself to thank for any misrepresentation. To write a summary is a useful exercise in selection and compression. I have known a three-hundred word summary sent in with a thousand-word article. It must be added that no new idea whatsoever should be introduced into the summary.

Some authors provide most intimidating obstacles to the reading of their own work by inserting table after table of data in the text. They slam them down with some helpful remark such as "plot error (percentage) 5.42, significant difference 24.32", and at once scurry on to lay another minefield. There is, moreover, a temptation, especially for those to whom the methods are still novel, to put details of statistical working. I have done it myself and have been sorry afterwards. Some do these things, I think, because they feel, not always consciously, that they give an imposing professional air to the paper; others through mere disregard of other people's mental needs. However well versed a reader may be in the subject of the paper he will be saved time if the author picks out what he regards as the significant features of each table and presents them in a short paragraph: a layman reading the paper will be lost without such an aid. If the author finds he cannot present the essence of his tabulated data in a few words, his basis of tabulation is wrong. By these means the reader picks up clue after clue as he goes along without having to grope for them.

To some extent it is out of date to fill a paper with tables. The Imperial Bureaux and the great museums are nowadays ready to file original data and a note to this effect in the paper will always guide the serious student to this source. Another method of dealing with tabulated data is to give them an appendix, keeping in the text only those essential to the argument.

One small point applies to figures as well as tables, and especially when they are to be published on a page smaller than this. They

should not be referred to in the text as "the following figure" or "the above table", but numberered and always referred to by their number. The printer may not be able to get each table in the same place in the text as it had in the manuscript and may have to put it on another page.

One of the easiest mistakes for an author writing in East Africa is to be too parochial. Any article that is good—or that has a title suggesting that it might be—will be read at one time and another by as many "outsiders" as by local inhabitants. Anyone "writing up" local work, especially when publication is sought outside East Africa, must realize that most people have no idea what the country is like, or, at any rate, what are its significant features for the piece of work in hand: and they do not know where most of the places are. Unless they are told at the outset they cannot fully grasp the exposition and they may be actively irritated.

The parochial habit of mind shows itself in a plentiful use of vernacular words, without explanation, and of local weights and measures, without equivalent. I have seen a contribution about native agriculture in Nyasaland that was so full of what I suppose may have been *Chinyanja* that half the time one had no idea what the author was talking about. Some of the excellent agricultural literature from the Netherlands East Indies is marred by the use of Indonesian words. Again, what do yields convey when they are stated in maunds per acre, or kilograms per arpent, let alone ardebs per dunum? (Bulletins and annual reports of departments are the worst offenders in this respect.) We are no better when we offer recipes in ounces to the debe or record yields in bags and bushels. What do you suppose a South American or Continental reader makes of these tricky measures? Will he know that when an East African talks of a bag of potatoes he means 180 lb. and a South African 150 lb.? By all means use local terms in a local journal if it will make your readers feel more at home; but the first time each one is used translate it for the benefit of those who are not in the know.

This leads naturally to a consideration of titles. They should be short, but they must also be informative and precise. I have seen an article entitled "Whither away?" that according to the text should have been "Goats are a curse to the land". A title is often marred by parochialism. Here are three specimens: "Berseem seed production", "The *chitamene* system", "The cattle *hat*". Another type makes impossible demands on geographical knowledge. For example: "Stock Improvement at Garba Tula". Even East African readers may not know where Garba Tula is. And how much better if the title can give an indication whether the work is of speeial interest to stockmen in a hot climate or a cool, a dry climate or a wet. Titles that begin "Some preliminary notes on . . .", or, much worse, "Random notes on . . .", are irritating. I understand that the author does not wish to arouse expectations that will not be fulfilled, but he would do better to drop "Some preliminary" and "Random" from the title and get his self-abasement over in his opening paragraph.

Quotations need careful handling. With two modifications the rule is that they must follow the original exactly, word for word. Words that are in the original may be omitted if their absence is indicated by dots; and if one or two words need to be added to the original in order to make its applicability clear they may be inserted in square brackets. The closing inverted commas of a quotation are liable to be omitted or misplaced. If the quoted words form only a part of a sentence, even though the final part, the closing inverted commas come before the full stop; if an entire sentence is quotation the full stop precedes the inverted commas. A similar rule governs the placing of the inverted commas in clauses ending with comma, semi-colon or colon.

There are often questions about the form in which an author should cite the references at the end of his paper. Many journals, especially those of the highest scientific class, standardize the form rigidly. In this journal we never have, asking only that each reference should be complete in itself and that the author should be consistent.* A sure way to pinprick an editor is to send in a list of references in which the word "Journal" is variously abbreviated to "Journ.", "Jnl.", and "J." Someone has to alter these things or the printed result would be untidy.

* The policy of this Journal is to adopt the following system, whenever possible, in citing literature. All works cited are given as a list at the end of the article. This list should be arranged alphabetically by authors' surnames followed by initials, date of publication, title of article, name, volume and page number of journal in which the article appeared, or, in the case of a book, its title, place of publication and edition number. The list of citations should be numbered in sequence so that reference in the text to any one of them can be made by quoting its number.—*Editor.*

Personally I have strong preferences for a particular form of citation, with which most British publications do not agree. In the first place I would banish Roman numerals utterly; they are a source of mistakes in every stage of their use. The best scientific journals in the United Kingdom keep "ser." (for series), omit "vol.", but print the volume number in specially heavy type. This I find in practice to be unnecessary for bibliographical work (as well as a nuisance to the type-setter). The simple notation favoured in the U.S.A., for example (2) 50 : 23-27, meaning "series 2, volume 50, pages 23-27", is completely clear. Titles of journals are supposed to be abbreviated in conformity with the principles in the *World list of scientific periodicals*. Most people do not have access to this and naturally tend to use as model any list of references that is handy. One innovation of the World list system is bad: the use of capitals for substantives and "smalls" for adjectives, which involves writing *Proc. zool. Soc.* and *Ann. Mag. nat. Hist.* I cannot see that this serves any useful purpose.

Now for some more personal likes and dislikes on minor points of composition.

There was a time when a writer in a scientific journal never used the first person. You still find many who go to any lengths to avoid it. The reason is, I think, sometimes false modesty, sometimes real; and sometimes that habit of mind which hesitates to come out with a thumping "I believe" or "I know". The alternatives are bad. We get the cumbrous "in the opinion of the present writer". This is at least unambiguous, but the same cannot be said of such phrases as "it is believed", which may mean that it is the opinion either of the author alone or of an unspecified population. Even "in the opinion of the author" sometimes appears in such a context that the reader is left guessing whether it refers to the writer or to an author just cited in the text. For all these reasons I prefer the personal pronoun every time.

A frequent error is to use too many adverbs. It seems to be due to two opposite casts of mind, the one that is prone to exaggerate and the one that wants to hedge and to modify every statement. An outstanding example of the first is provided by an ornithologist, a good taxonomist with an enviable eye for nuances of colour. He sees clearly differences that are barely perceptible to other people, and he has acquired the habit of describing specimens as "altogether paler" or " showing a very strong difference". "Rather", "considerably". "undoubtedly" are all overworked; "absolutely" is rarely justified; "quite" is feeble and equivocal. With this sort of adverb must be classed two or three adverbial phrases. Why need anyone write "smooth in texture", "blue in colour"? Away with them. But "cream-coloured" is admissible. At one time I used to go through my own articles with the especial object of cutting out unnecessary adverbs. Large numbers of them went.

Italics are used by some contributors in order to emphasize certain words in a sentence. This is the letter-writing device of a Victorian aunt and it cannot be allowed in serious work. An author resorts to it for one or both of the following reasons: he underestimates the intelligence of his readers, or he has failed so to contruct his sentence as to bring out his point with the force he would like.

Hyphens are not used enough. They are needed whenever two words are connected in the author's mind and made to do duty as an adjective. Sometimes the meaning is obscured if the hyphen is left out; more often the lack of the hyphen causes the reader to hesitate momentarily. "A native authority maize improvement scheme" is more quickly grasped if there is a hyphen after "native" and one after "maize". Try also "one man pick up balers". There is not much difficulty in deciding where hyphens are needed. In reading aloud the voice puts the emphasis on the first of a pair of linked words and tends to slur the second. No one reads "large-scale map" with the same evenness of tone as he does "poor old Joe". Sometimes two hyphens are needed, as in "a three-year-old sheep".

"Case" is an overworked word. It is often necessary, but more often it is not, and is a mark of ill-knit writing. "In the case of sorghum, a good yield is often obtained in a dry year" is better altered to "Sorghum often yields well in a dry year". This example serves also to point the advantage of direct construction, avoiding the abstract noun "yield" and the passive verb.

"Phenomenon" and "phenomenal" are pretentious words that are hardly ever necessary and are often misused. A "phenomenally good yield" is an unusually or remarkably good one. A "phenomenal yield" might strictly be unusually good or unusually bad, but it is regularly used to mean the former. "Phenomenon" turns up in such phrases as "The occurrence of this insect in Uganda is

a remarkable phenomenon". The cure is to cut out "phenomenon" and its article. I cannot resist quoting again a specimen that recently appeared in "Write simply". Of the potato plant someone wrote "Sprouting and water uptake are simultaneous and non-separable phenomena".

I dislike the extent to which "maximum" and "minimum" and "optimum" have pushed themselves into use. The first two are often handy and legitimate, but often they are not. We have nearly forgotten that the maximum yield and the minimum used to be called the highest and the lowest; or that "the maximum efforts of which we are capable" were "our utmost efforts". "Optimum" is usually only a mouthy substitute for "the best".

I have an intense dislike for the word "conditions". It is often justifiable or necessary; equally often it is not. "Soil conditions" is as a rule correctly used, meaning "conditions in the soil". "Climatic conditions", a term one constantly meets, is always wrong. "Climate" itself is defined in the Oxford English Dictionary as "conditions of temperature, dryness, etc." As a rule the term "climatic conditions" is used when weather is meant; on other occasions it means "climate", the summation of weather. "Conditions" makes another unwanted appearance in the favourite phrase "Under East African conditions". The author never means that; he could not define "East African conditions" if you asked him. He means "in East Africa", or "in the bit of East Africa I know", or even "on European farms in Kenya". What are "drought conditions" but plain "drought", except on the rare occasions when physiological drought is in mind?

Some people tackle a wide general subject without making any effort to master the essential literature, and a worker away from a good library is under a serious handicap. A sympathetic editor can do much for a contributor who has good ideas or has made interesting observations, but does not know how to arrange his material. Some authors take kindly to suggestions and do not shirk the always uncongenial task of rewriting an article. The author it is difficult to have patience with is one who does not check the typescript carefully before sending it in. Other authors will give a plant name a capital in one line and not in the next, or use grammes, grams and gm. indiscriminately in the same article.

Few of us are capable of criticizing our own work adequately. We come nearest to doing so on re-reading it after an interval; then we are liable to be astounded by our own work, appalled at depths of fatuity or delighted with flashes of insight that we fear we can never again achieve.

But most contributors to a journal like ours will not bear this putting aside to mature for later tasting. The alternative is to get other people to read the contribution in draft. My own idea is that at least two people should read it, an expert and an intelligent layman. The first is sufficiently well-versed in the subject to be able to pounce on technical errors. In this connexion it is occasionally the editor's privilege to save a contributor's reputation as well as to stop him from misleading our readers; but authors obviously should not rely on this happening. The second referee, the layman, represents the majority of potential readers and his approval will ensure that the author has omitted none of the facts necessary for an understanding of his paper and has not assumed on the part of the reader technical knowledge he can hardly possess. Incidentally, it is not rare for the layman, bringing a fresh mind to the subject, to make useful constructive suggestions.

There is still another test that the author should apply, in some respects the most valuable of all, namely to read his paper aloud; this is apt to be chastening as well as instructive. Even if he only reads it to himself this proceeding will reveal, as nothing else will, needless repetition, bad punctuation, clumsy construction and awkward transition. If the article flows smoothly it will penetrate the understanding more easily. This, by the way, is a good stage at which to eliminate remarks about which an author has a lingering doubt. Sometimes in the heat of composition he makes a smart remark or a hazardous deduction that he never is entirely happy about, even though he is proud of it. There is no recommendation sounder than "when it doubt, cut it out".

EDITOR'S NOTE

It is regretted that Mr. R. E. Moreau has had to give up his work as Assistant Editor owing to ill-health. Since this Journal was first published in 1935 he has been largely responsible for the editorial work, and we are glad to take this opportunity of recording our appreciation of his valuable services. He has set a high standard of editing which may not be easy for his successors to maintain.

ONION CULTIVATION ON KILIMANJARO

By R. J. M. Swynnerton, M.C., Agricultural Officer, Tanganyika

(*Received for publication on 29th October*, 1946)

During the war years the production of onions has assumed increasing proportions in the Northern Province and the average crop has risen from about 1,000 tons to over 2,000 tons per annum, of which rather more than half is produced in the Moshi district. The annual value of this crop is over £30,000 and the variety grown is Bombay Red, the seed of which is imported from India and is supplemented by seed produced by the Agricultural Department in the Mbulu district, and to a certain extent by the growers themselves. Bombay Red is a hardy onion, a good yielder, stores well for periods up to six or eight months, and has a comparatively thick skin which is good for handling. Its main fault is that it is highly susceptible to thrips attack.

In 1940 Mr. J. R. Curry [1] produced a departmental leaflet on "Onion Cultivation" in both English and Kiswahili and the observations made in this paper aim to supplement this in the light of subsequent experience. Based on observation plots laid down in 1942 by Mr. J. G. M. King, Agricultural Officer, a series of experiments on the cultivation of onions has been carried out in the Moshi district. There are three essentials to good onion cultivation, ample moisture, clean cultivation and liberal manuring. There is plenty of scope and inducement for improved cultivation locally. Average fair yields in the Nasik and Poona districts of India, growing the identical onion that we do, are said to range from 5.8 to 8.9 tons per acre, while under good cultivation yields of 11.1 to 17.8 tons per acre are obtained. In the Moshi onion experiments the following yields have been obtained:—

	1942	1945	1946
	tons	tons	tons
Overall average	6·52	6·89	3·08
Best treatment	12·71	10·11	5·67

The low yields in 1946 are accounted for by the very severe drought which extended for nine months from 1945 till April, 1946, and brought on a bad attack of thrips which wiped out many onion plantations.

Nurseries.—Following a year in which the short rains have failed, onions may be expected to suffer a severe attack of thrips. In such years onion nurseries should not be sown before the middle of February because it will not be possible to transplant them until the commencement of the rains on account of lack of water in the rivers and furrows. If the seedlings stand too long in the nurseries after they are ready for transplanting they will become infested with thrips at this stage, which will cause severe damage after transplanting and will produce little or no crop. Also if onions stand too long in the nursery they start to form small bulbs and such seedlings can never produce marketable onions.

Onions should be maintained in a vigorous state of growth in the nursery by regular watering, and where they show signs of unthriftiness the application of half a cigarette tin full (¼ lb.) of sulphate of ammonia to beds 4 ft. wide by 18 ft. long is a good stimulant. As soon as the seedlings are nine inches high, at about eight to ten weeks old, they should be transplanted.

Transplanting.—If transplanting is undertaken in dry weather, both the nursery and the onion beds should be well soaked the day before. Failure to do so will give the plants a serious check. The seedlings, brought in bundles from the nursery, should be picked over to remove all seedlings showing a marked swelling of the bulb and all small unthrifty seedlings. Select healthy seedlings about nine inches long for planting and cut the tops back to about six inches.

It is most important that the seedlings be planted at nursery level and pressed firmly into the ground. On no account should they be planted too deeply because this reduces the yield. Except in rainy weather, the seedlings should be watered within an hour or two of transplanting.

Methods of Planting.—While the Chagga cultivate their onions on flat beds, as described below, experiments have been carried out on the methods of cultivation used in other onion-growing countries. Although the Chagga method of cultivation regularly produced the greatest yields of onions per acre because of the closer spacing, methods in which onions are grown on ridges are useful for producing onions of the larger "household" and "hotel"

sizes and also for counteracting waterlogging in wet seasons. The following is a description of the methods of cultivation tried out:—

Chagga.—Onions are transplanted into low, flat beds 3 to 5 ft. wide and 18 ft. long. Irrigation is done between these low beds, the water being thrown up on to the plants by means of a scoop. Spacing is 4 to 5 in. between plants.

Indian I.—The delta system. Seedlings are transplanted into flat beds which are surrounded by ridges similar to rice beds. Irrigation is done by flooding the beds. Onions are liable to suffer from waterlogging in a wet year.

Bermuda.—Onions are grown on the crests of low, small ridges which are 14 in. apart, the distance between plants in rows being 4 to 5 in. Irrigation is done between the ridges. Gives a crop of well-grown onions and in wet seasons this method has considerable advantages.

Indian II.—Seedlings are transplanted on to flat-topped ridges 18 inches wide with two rows of onions nine inches apart. Irrigation is done between the ridges. This method involves considerable maintenance work but avoids waterlogging in wet seasons.

Cyprus.—Seedlings are transplanted on to round ridges, 3 ft. apart, similar to potato ridges. Two rows of plants per ridge, plants 4 in. apart in the rows. Irrigation is done between the ridges. Involves considerable maintenance work, but avoids waterlogging in wet seasons.

The results of experimental work with the above methods of planting onions may be summarized as follows:—

Yield of Dry Onions per Acre

	1942		1945		1946	
	Tons	%	Tons	%	Tons	%
Chagga ..	9·07	216	6·58	114	4·05	183
Indian II	6·20	147	6·19	107	3·14	142
Bermuda..	4·21	100	5·79	100	2·21	100
Cyprus ..	6·25	149	4·80	83	—	—
Indian I ..	6·63	147	5·17	89	—	—

These results indicate that the Chagga method of planting onions on low, flat beds is well suited to the area, provided the seedlings are transplanted at the correct nursery level.

Spacing.—For the Bombay Red variety of onion grown in the Northern Province experiments have shown that the best yields from the Chagga flat beds are obtained by planting the seedlings in rows 4½ to 6 in. apart and 4 to 5 in. apart within the rows. This produces the best yields of mixed grades of onions, wider spacings giving a lower tonnage of larger sized onions. The results of the spacing trials may be summarized as follows:—

Yield of Dry Onions per Acre

	1945		1946	
	Tons	%	Tons	%
4½ in. between rows ..	9·79	131	4·96	121
6 in. between rows ..	7·91	106	4·40	108
7½ in. between rows ..	7·45	100	4·09	100
in. between rows ..	6·42	86	—	—

Manuring with Sulphate of Ammonia.—Vigorous growth must be maintained in the onions and this can be brought about by regular watering, weeding and the application of sulphate of ammonia. Onion beds should be flooded at regular intervals in dry spells during the rains and thereafter until harvest and the soil should never be allowed to dry out.

Experiments over three years in Moshi show that the application of sulphate of ammonia to the onion beds within the first month or six weeks gives a great stimulus to the onion plants. Within ten days or a fortnight after application treated beds can readily be picked out by eye from untreated on account of their healthy, deep blue-green colour. Only small quantities of sulphate of ammonia are required, and it is recommended that for onion beds 4 ft. wide by 18 ft. long a quarter of a pound, or half a cigarette tin full (1 cwt. per acre) be applied fourteen days after transplanting to stimulate the plants after their check from transplanting and a second application of equal quantity be applied six weeks after transplanting to counteract the effects of waterlogging and the leaching of nitrates caused by the main rains. Application of sulphate of ammonia more than six weeks after transplanting is not recommended as it does not increase the yields of onions significantly. Even in a year, such as 1946, when thrips attack is so bad as to wipe out many onion plots, the application of sulphate of ammonia, while not controlling the thrips, stimulates the development of the bulb in the early stages of growth before the thrips have crippled the leaf system and thereby raises the yields of onions appreciably. The following table shows the benefits derived in the Moshi experiments from sulphate of ammonia:—

Yield of Dry Onions per Acre

	1942		1945		1946	
	Tons	%	Tons	%	Ton	%
No manure	6·00	100	5·27	100	2·82	100
1 cwt. S/A per acre..	—	—	—	—	4·13	157
2 cwt. S/A per acre..	12·71	212	10·11	192	3,90	139

In 1946 the application of sulphate of ammonia was included in the spacing and method of planting trials, but no significant interaction was found.

The price of sulphate of ammonia is under Sh. 20 per cwt., so that there is a profit to the grower of over Sh. 200 per acre from the increased yield brought about by applying 1 cwt. of sulphate of ammonia per acre even in a bad year, such as 1946, if the price of onions is calculated at Sh. 3 per *frasila* (about 35 lb.), although in the current season the price has been double this figure.

If the small grower wishes to purchase sulphate of ammonia he should calculate ½ lb. sulphate of ammonia for each onion bed. He should then apply half a cigarette tin full 14 days after transplanting and half a cigarette tin full one month later. The price of 1 lb. of sulphate of ammonia will be under 20 cents.

Sulphate of ammonia is best applied dry by scattering it lightly by hand over the onion beds and then watering it in. There is no advantage in applying it dissolved in water. The onion beds should be watered very carefully afterwards so that the sulphate of ammonia soaks into the soil and is not washed away by excessive water.

Thrips.—Onions ordinarily are very susceptible to thrips attack. In Moshi, once or twice in five years after a failure of the short rains, thrips is liable to be very severe and reduce the crop from one-half to two-thirds and to a lesser degree every year. Under these conditions great care must be taken not to plant onion nurseries too early and not to allow the seedlings to stand overlong in the nurseries after they are ready for transplanting. Vigorous growth must be maintained by regular irrigation in dry weather, regular weeding and scuffling of the soil to prevent caking and the application of sulphate of ammonia soon after transplanting, as advised above. Although spraying with tartar emetic has been recommended for thrips control, two experiments laid down in 1946 proved that it effected no control whatsoever and this was confirmed in the onion seed plantations of the Agricultural Department in Mbulu district. Investigation into the modern sprays developed during the war is to be undertaken. As the thrips secrete themselves between the tightly clasped young leaves of the onion plants, selection of onions with wide spreading habit should be beneficial both for depriving them of a hide-out and to permit sprays to penetrate.

In a season in which thrips attack is bad the Chagga sell their onions soon after harvest, as it is said that they do not store well after thrips attack.

There are indications, however, that a spray or dust for the control of thrips suitable to local conditions will be found, as in India [3] nicotine sulphate spray has caused 82 per cent mortality and in New South Wales [2] D.D.T. spray at 0.1 per cent concentration gave yield increases of from 26.8 to 75 per cent. Although dusting would appear to be more convenient for treating numerous small native plots, 3 per cent nicotine in India and 1 per cent D.D.T. in New South Wales were far less effective than spraying. The New South Wales experiments confirmed the unsuitability of tartar emetic spraying.

In 1941 Mr. J. G. M. King, Agricultural Officer, undertook a survey in areas in the Moshi district which had been severely infested with thrips and confirmed that where onions had been transplanted late after the onions had stood a long time in the nursery, the plantations were virtually wiped out by the thrips. The following summarizes the results of this survey: Number of plots measured, 56; average size of 56 plots, 1,043 sq. yds.; mean yield of 56 plots, 1,665 lb. per acre; yield of 34 medium plots, 2,390 lb. per acre; yield of 22 poor plots, 545 lb. per acre.

These figures give an indication of the seriousness of the damage caused by thrips and the scope for improved cultivation and thrips control and were confirmed by the following check which was made on the onion plots of 1,707 growers in Old Moshi, Mbokom and Uru, three out of the five onion growing areas of Kilimanjaro: Medium crop 609 growers, poor crop 544 growers, no crop 554 growers.

Storage.—The Bombay variety of onion stores well for six to nine months but loses from 30 to 50 per cent of its weight during this period from shrinkage and decay. In the Northern Province in the recent war years the

price has fluctuated from Sh. 7 per *frasila* at the beginning of the season in July and August down to below Sh. 3 per *frasila* when the main crop comes in, and then in February and March when onions become scarce again may rise to as much as Sh. 9 per *frasila*. Storage, therefore, has an important part to play in the cultivation of onions, either in stabilizing supplies to the market or enabling the grower to secure the higher off-season prices. Where predial larceny is not prevalent the grower can leave his onions out in the field to dry after harvest, preventing sun scorch by covering the bulbs of one row with the leaves of the next.

Whether the onions are disposed of for export or retained for storage, they must first be well dried, and sun scorch must be avoided. When thoroughly dry, after ten days or a fortnight, they should be spread out on a cement floor, or on wooden trays, or in the roof of a hut to a depth of not more than one foot. A better method is to dry the onions with their leaves on and then to tie them into bunches by their leaves and hang them over strings in a hut or store. In this way wastage is reduced and the onions may be stored until prices are good.

Grading.—Onions fetch better prices if the grower and exporter caters for the particular market which he wishes to supply. Growers and exporters, therefore, should grade their onions into uniform sizes and the following are the four categories at which they should aim: hotel onions, not more than 6 by weight per lb.; household onions, not more than 12 by weight per pound; bazaar onions, not more than 22 by weight per lb.; pickling onions, exceeding 22 by weight per lb.

It has already been shown that to produce the larger grades of onions, which fetch a better price in the shops and involve less wastage to the housekeeper, manuring with sulphate of ammonia and either growing onions on ridges or at rather wider spacings than in the normal Chagga flat bed method must be practised.

Prices.—Before the war onions were produced in such large quantities in India, Egypt and Ceylon that they could be sold at a much cheaper price than the Tanganyika onion. When trading conditions become more normal, Northern Province onion growers will have to be prepared to face severe competition, as the following prices of onions landed in Zanzibar, excluding duty, show:—

Source	Price per Frasila	
	1938	1940
	Sh. cts.	*Sh. cts.*
India	2/25	2/60
Egypt	2/60	3/35
Tanganyika	3/95	5/80

It is of great importance, therefore, that onion growers should raise their yields per acre to the greatest extent possible by improved methods of cultivation, by manuring with sulphate of ammonia and by thrips control to counteract any reduction in price brought about by competition with imports into East Africa from overseas and by storage and grading in order to put the best quality of onion on to the market at a time of shortage.

REFERENCES

[1] Curry, J. R.—"Onion Cultivation", *Leaflet No.* 14, Department of Agriculture, Tanganyika.

[2] Hely, P. C.—"Control of *Thrips tabaci* on Onions", *Agric. Gazetteer of New South Wales*, Vol. LVII, Pt. 9, 1946.

[3] Rahman, K. A., and Anshi Lal Batra.—"The Onion Thrips", *Ind. J. Agr. Sci.*, XIV, Pt. 4, August, 1944.

ONE VIEW OF AN ENTOMOLOGIST

A coxcomb, he has studied these twenty years about the nature of lice, spiders and insects. . . No man upon the face of the earth is so well seen in the nature of ants, flies, humble-bees, earwigs, hoglice, maggots, mites in cheese, tadpoles, newts, spiders, and all the products of the sun by equivocal generation. This foolish virtuoso does not consider that one bricklayer is worth forty philosophers.

Thomas Shadwell, 1676,
quoted by Lord Rayleigh in *Nature*

Never attempt to screen an insufficiency of knowledge even by the most audacious surmise and hypothesis. Howsoever this soap-bubble will rejoice your eyes by its play, it inevitably will burst and you will have nothing but shame.

Perfect as is the wing of a bird it could never rise the bird up without resting on air. Facts are the air of a scientist. Without them you never can fly. Without them your theories are vain efforts.

Ivan Pavlov,
in an address to Russian students.

THE EVALUATION OF LAND FOR UTILIZATION

A recent publication by G. V. Jacks of the Imperial Bureau of Soil Science* reviews land classification in the sense of "the grouping of lands according to their suitability for producing plants of economic importance". This type of stock-taking is an essential prelude to sound long-term development plans, and is of particular importance in the British Colonial Empire at the present time. As the author points out, land-use planning is very much in vogue at present, but few of these plans based on systematic land classification have been put into practice. Development schemes are too frequently drawn up without the basic knowledge necessary for sound planning, and then there is no time to take stock of the resources before the scheme comes into operation. But "blind" stock-taking is not the answer, since the foremost essential in the land classification should be "a clear and complete definition of why the proposed classification is needed and how it will be used when completed". Thus land must be classified with a specific object in view, and the method of classification will vary according to what that object is. All methods, however, have a common basis in that "every land-use plan for exploiting the agricultural and forest resources of a region for the lasting benefit of the occupiers must be based on the conservation of soil fertility".

On farm lands in Europe which have been cultivated for a thousand years, mostly by good methods of husbandry, the mere maintenance of fertility may be sufficient, but large areas of the African dependencies do not possess enough natural fertility to give high enough yields to allow for improvement of social and nutritional conditions. The raising of fertility, as well as its conservation, must play an important part in land-use planning in Colonial agricultural development. For instance, grass rotation is clearly the best method of conserving fertility, but a temporary ley will not change an inherently poor soil into a good one. In many districts there is a fundamental deficiency of one or more of the major plant nutrients, calcium, phosphate, nitrogen, and potash, and these will have to be "imported", either by applying cattle manure produced from the grass of surrounding areas, or by adding inorganic fertilizers in a conservative crop rotation.

In dealing with this point Jacks says "man can easily change the level of fertility up or down. . . .In theory, every soil can be brought by appropriate measures to the optimal state of fertility, but in practice the application of the required measures is often limited by economic factors. The Sahara could be made fertile by irrigation and manuring, but it would not pay". Thus, in assessing the potential value of tropical soils their present fertility is only one factor amongst many. A poor soil within a few miles of a cheap supply of fertilizers could be economically turned into a better one, but it might not pay to improve a richer soil, deficient in phosphate, which is a thousand miles by road from the nearest source of phosphatic fertilizers. In the same way a fertile soil which is five hundred miles by road from the nearest market or port of export is not so rich from the point of view of land planning as is a less fertile soil within a few miles of the market. The question then arises as to whether it is better to improve the communications to the fertile soil or to raise the fertility of the poorer one. This problem arises in many parts of East Africa, and the hunt for a "good soil" may play a small part in future planning.

In classifying agricultural land in East Africa, rainfall would be of primary importance, for it is obvious that a rich soil with a low rainfall has low potential fertility unless irrigation is feasible. Given an adequate and reliable rainfall, and cheap transport or a nearby market, the land-use value even of a poor soil is high. The use to which the land is to be put is another factor of importance, and the recent inquiry into the possibility of large-scale production of groundnuts in East Africa is an interesting case in point. The groundnut requires a light sandy soil of moderate to low fertility, and although it must have an "adequate" rainfall it requires rain for only four months in the year. Thus a relatively poor soil, with only 15–20 inches of rain per annum, would be suitable if the rainfall was confined to four months in the year and was reliable and well distributed over the period. Land with these characteristics, and with good communications, would be potentially fertile for this purpose, but as a place for mixed farming it would be classed along with the deserts. If the groundnut scheme is put into effect it will probably make good use of land which is at present regarded as useless.

The incidence of tsetse flies is another important factor in land classification in East Africa. A fertile, well-watered soil in an area

* "Land Classification for Land-use Planning", by G. V. Jacks. Imperial Bureau of Soil Science Technical Communication N. 43, pp. 90, price Sh. 4.

infested with tsetse would be useless for individualistic small-scale native mixed farming, because very large areas must be kept clear of bush and trees in order to prevent trypanosomiasis in live stock and sleeping sickness in man. For very large-scale plantation agriculture, such as the proposed groundnut scheme, and for controlled native agriculture as is found in the sleeping sickness settlements, the value of such land is quite high.

The relationship between land classification and soil surveys is fully discussed by Jacks, and it is of interest to us in East Africa that considerable prominence is given to the views of the late Geoffrey Milne. In his report on a visit to the United States in 1938, Milne describes the U.S. soil surveyor's approach to land classification as follows: "The soil surveyor regards himself as a student of the land, who, being a soil scientist first, distinguishes his land types primarily by soil profile. . . . In this stage of his work he is a pure pedologist, adding to soil knowledge or establishing the validity of existing concepts on new ground. . . . As he goes about in the field plotting soil-type occurrences, he must, however, bear in mind that he will have the further duty of making it clear, for all who follow him on land questions, what the significance of his data is. . . . He must, therefore, pay attention to a good deal besides soil profile. His land types are finally to be so defined (having regard to the limitations of the scale on which he is working) that the most desirable use of them can be inferred by other specialists (such as agronomists, foresters, or the administrators whom they advise) simply by superimposing their own particular technical knowledge on the pattern he has provided. . . . There is clearly a wide field of relevant inquiry here: crop plant behaviour, crop yields and qualities; thriftiness of stock, stock-carrying capacity, rates of natural increase; population densities, human health, and attainable standards of life earned on the land. . . ."

Only very small areas in East Africa could be classified in this way, and the co-operation of several departments would be required. There is, however, another angle from which land utilization can be approached. In Tanganyika an administrative officer and an agricultural officer collaborated to produce a soil map of a thickly populated area which is of considerable economic importance. The field work was carried out by an African surveyor, who merely plotted the different soils as the natives know them, retaining their native names. As it happens, these particular soils are easy to distinguish by eye, and they are grouped in a mosaic which bears a regular relationship to topography—what Milne called a "catena". No knowledge of soil science was required by the surveyor, or even by those who were responsible for the survey, but the resulting map was of the greatest value to administrative and technical officers, since the general value of each soil type is known to those who are familiar with the area. This map has not been published because it would be unintelligible to any one outside that particular province, but the mention of the native name of one of the soil types would convey to a man working in the area a number of related factors which would raise it from a soil type into a land type. Thus land classification is possible without the help of a soil scientist.

Jacks mentions that the standard U.S. soil survey "has, in fact, developed into a combination of a soil survey proper with a land-type inventory", and its results "form the factual basis in the development of sound programmes of land use. Soil surveyors are constantly reminded that it is the land rather than the soil that is to be investigated, classified, inventoried, and interpreted, primarily though not exclusively by the soil profile". This trend towards a combination of soil survey and land classification has affected the definition of soil types, since the texture of the soil, apart from its genetic type, is important. The name "Hagerstown sandy loam", for example, would convey little to a soil surveyor in Africa, but it means a great deal to any one planning land use in that part of the United States. In the same way "Kikuyu red loam" is enough to convey to the Kenya settler the general value of that soil type, even although he may not know that it is a laterized red earth with a silica : alumina ratio of 2.0 in the clay fraction. Yet from the latter description soil scientists in other parts of the tropics can visualize the soil and have a rough idea of its agricultural value. The prevailing trend in America is to "charge the soil type with the maximum load of meaning", irrespective of whether or not that meaning can easily be read by workers in other countries or even in other parts of the same country.

Ecological surveys as well as soil surveys are used as a basis for land classification; as an example Trapnell's ecological surveys in Northern Rhodesia are now providing a foundation for detailed economic surveys and for native re-settlement schemes. There has been some controversy about the value of "indicator plants" in land classification, and soil scientists are apt to doubt the value of these. The explanation may be that the pseudo-botanist with a limited repertoire of impressive Latin plant names will use the presence of one or

two particular species as an indication of soil fertility, whereas the ecologist deals with the association of a large number of species, and thereby obtains a better idea of the general characters of the area. On this subject Jacks says "There is in general a close correspondence between natural vegetation and genetic soil type. The advantage of using the vegetation rather than the soil as an indicator is that small but significant differences are more immediately obvious in the vegetation". Investigations in Europe have shown that plant associations reflect the moisture condition of the area more clearly than they do the nutrient status of the soil. This means that the ecologist may obtain a truer picture of the area than a soil chemist would from analysis of the soil. Soil analysis will indicate how the fertility of the soil might be raised, but its present fertility depends on more than its nutrient status.

Land-use has frequently been studied by means of agricultural surveys, and an example of this which is well worthy of mention comes from Uganda*. A number of small areas, carrying populations of 150 to 1,000 people, were surveyed in order to find out whether the pressure on the land was excessive, the land types being known as elephant grass and short grass areas. In East Africa much "land classification" has been done by the native cultivators themselves, and this distinction between long-grass and short-grass land types is one which is widely used throughout this territorial group. The natives had already planned their own land-use, by adapting their crops and their cultivation methods to the different land types. Land misuse is then largely a matter of overcrowding and of wasteful methods of husbandry, and the Uganda surveys showed that nearly half the areas were overcrowded on both land types, but land requirements on the elephant grass type were substantially less than in the short-grass area. On both land types these requirements could be greatly reduced by improving the agricultural systems.

The evaluation of a soil for land-use planning is not easy. As has been pointed out, chemical analysis may indicate a poor soil, but a favourable climate may raise its fertility above the level indicated. For the same reason luxuriant natural vegetation may seem to indicate a fertile soil when in reality the climate may make the best of a poor soil. This point is brought out in the 1897 annual report of the Department of Agriculture, Zanzibar. A sample of soil from the Mwera valley had been sent to Dr. A. J. Voelcker, who was then consulting chemist to the Royal Agricultural Society of England. In his report on the soil, Dr. Voelcker stated: "Judging its composition by the foregoing analytical figures it will be seen it is one of a miserably poor character, and has every evidence of being a thoroughly exhausted soil". Mr. R. N. Lyne, then Director of Agriculture in Zanzibar, pointed out to Dr. Voelcker that generally speaking the vegetation on this soil was very luxuriant, and that this fact might be accounted for by the abundant and well-balanced supply of sun and rain. In reply Dr. Voelcker wrote: "I note with interest what you say with regard to crop production under favourable climatic conditions although a soil may be intrinsically poor. I was much struck by the same fact when a few years ago in India, and it is very evident that these conditions must have a most marked influence in enabling crops to supply themselves with food. There can be no doubt, I think, that under such conditions what food supplies there are in the soil become more quickly available than where we have such a climate and physical conditions of soil to deal with as are met with in England".

In this review emphasis has been laid on the underlying principles of land valuation, but these form only a small part of the publication. Although the author has included extensive notes on the methods of land classification used in Europe and America, these cannot be applied in tropical countries without some adaptation, and the fundamentals on which they are based are perhaps not sufficiently well appreciated in East Africa. It is not enough to draw up a questionnaire like a census return; the broader planning of the territory as a whole must precede the evaluation of land. The question "what can we do with this land?" cannot be answered unless the place of the district in a broader economic plan has been summed up first. A district in which industrial or mining developments are to take place, or an area through which it is proposed to run a new railway, cannot be valued for land-use without considerable knowledge of the development plan. In temperate countries plans are usually drawn up to improve areas which have already reached an advanced stage of development, whereas many of the proposed schemes for East Africa deal with areas the potentialities of which are at present practically unknown.

D. W. DUTHIE.

* "A report on 19 surveys done in small agricultural areas in Uganda with a view to ascertaining the position with regard to soil deterioration" by J. D. Tothill and members of the Department of Agriculture, Uganda, 1938, Government Printer, Entebbe.

RAT CONTROL

In East Africa there are so many different kinds of rats that their individual fields of activity are circumscribed, and at times encroached upon, by their relatives. So that cosmopolitan house rat, the black *Rattus rattus rattus*, and the closely related sewer rat, the brownish *Rattus norvegicus*, stay, as a rule, near human habitations, godowns, dumps and other man-made haunts. The white-bellied *Rattus rattus alexandrinus*, known as the roof or tree rat does at times become a nuisance away from villages and the like, and will form large colonies in coco-nut palms.

As with many other animals which on being introduced into the Pacific Islands found greater scope for their activities than they had hitherto enjoyed, these three rats in Hawaii took to the fields. Without serious challenge from the local *Rattus hawaiiensis*, the black, the brown and the white bellied rats soon became field pests of the first order. The amount of damage they do each year to the extensive sugar cane fields of Hawaii has led to much research on control methods, and a recent paper by Doty* summarizes in an interesting and well illustrated manner the latest recommendations.

In Hawaii, as in Great Britain,† prebaiting has become a standard method of attack in organized rat control. For this, the bait to be used is made up without poison and then put out at fixed stations in the field. The prebaits are examined at intervals, the bait added to if almost all consumed, or replaced if mouldy. Then, when the rats have become accustomed to their new food supply, the prebaits are replaced with poison bait enough for one or at most two nights feeding. "A standard system of prebaiting and poisoning on farms (in England) which has given consistently good results is the 1-3-5 system; prebaiting on the first and third days, poisoning on the fifth, missing on the second and fourth days." In Hawaii the procedure is more lengthy. "On the first trip each station is placed and a measured amount of unpoisoned oats poured into each pan. . . . There is so little acceptance during the first two days of baiting that no useful purpose is served by inspecting the stations so soon, but after four days an inspection should be made to renew the oats, as the rats will have begun to feed more confidently. If at this time the grain is dirty, mouldy or otherwise unattractive it should be removed, and later weighed and discarded. Sufficient unpoisoned grain should be placed in the pans during this visit to assure a supply for another two or possibly three nights remaining before poisoning, otherwise the efficiency may be reduced. . . . The third visit should follow within two or three days, and at this time any remaining unpoisoned oats should be removed and the poisoned oats substituted. This poisoned grain should remain in the pans at least three days before the stations are removed from the field on the fourth and final visit." This means prebaiting on the first and fourth days, poisoning on the sixth or seventh, and removal of baits on the tenth day.

Prior to the war the bait which gave the best results in Hawaii was one made from rolled oats and thallium sulphate. Thallium sulphate is a poison which has to be handled with the greatest of care as it is absorbed through the skin. Shortage of supplies led to the use of zinc phosphide, which is also recommended by the Ministry of Agriculture. Barium carbonate and strychnine have fallen from favour as rat poisons owing to their unpalatability, and in the case of the former unreliability owing to varying composition. It is obvious that for effective use in the field a bait must be at least as attractive to the rats as the surrounding food, if any. The zinc phosphide bait which has proved at least as attractive as sugar cane in Hawaii is composed as follows:—

Pre-dried rolled oats: 100 lb.
Zinc phosphide: ½ lb.
Mill lime: ½ lb.
Corn oil or salad oil: ¾ gallon.

Raw linseed oil may be used instead of corn oil, but in that case the amount of lime used is increased to ½ lb. and the bait should not be stored, but used immediately. Bait made from oats which are not absolutely dry must also be used as soon as made. In any case, fresh bait is to be preferred to that which has been stored for any length of time.

A bait recommended by the Ministry of Agriculture is as follows:—

Ordinary "National" flour: 90 lb.
White sugar: 10 lb.
Zinc phosphide: 5 lb.

W.V.H.

* Doty, R. E., 1945, "Rat Control on Hawaiian Sugar Cane Plantations", *Bull. Expt. Station, Hawaiian Sugar Planters' Association.*

† "Rat Control on Farms", Ministry of Agriculture, 1945. "Extermination of Rats and Mice", Ministry of Food, 1944.

BREEDING CASSAVA FOR VIRUS RESISTANCE

By R. F. W. Nichols, East African Agricultural Research Institute, Amani, Tanganyika Territory

(*Received for publication on 20th August*, 1946)

Introduction

So long as cassava (*Manihot utilissima* Pohl.) continues to rank as a staple food for a large proportion of the indigenous population of East Africa, the improvement of the crop must figure in the agricultural economics of the country. The comparative freedom of the crop from pests, and its drought resisting qualities, render it of particular value as an "insurance policy" against famine when it is less afflicted by drought and locusts than other crops. That it is, however, subject to great reduction in yield, due to infection by the mosaic virus, has been recognized for many years. In Zanzibar, Briant and Johns (1940), have shown that the loss in a non-tolerant variety, propagated from diseased cuttings, may be as high as 95 per cent. Experimental work at Amani demonstrated that this virus was transmitted by a white fly, *Bemisia* sp. (Storey and Nichols, 1938); field experiments showed that natural infection was mainly seasonal and in certain areas extremely high. These experiments also demonstrated that some varieties are less prone to infection than others. This disease occurs throughout East Africa.

The existence of a second virus disease of cassava, known as brown streak, also transmitted by a white fly, was reported by Storey (1936, 1939). The destructiveness of this second virus, under certain conditions, can be very serious, and, in highly susceptible varieties, the effects may be lethal; while at the other end of the scale, tolerant varieties are only slightly affected. This disease is prevalent in the coastal areas of East Africa but its geographical limits inland are not yet known.

The existence of these two serious diseases clearly indicates the need for immune or at least highly resistant or tolerant varieties. As an initial step the problem was attacked by importing through the Central Quarantine Station, Amani, varieties from other tropical countries in the hope that some would prove better than the local ones. Over one hundred varieties were introduced from Brazil, British West Indies, Belgian Congo, Federated Malay States, Java, Madagascar, Mauritius and West Africa. With few exceptions these varieties proved highly susceptible to virus infection; importation of cassava varieties was, therefore, discontinued.

It was then decided to approach the problem from the practical plant breeding aspect. This project had the support of both Sir Frank Stockdale, then Agricultural Adviser to the Secretary of State for the Colonies, and Mr. S. F. Ashby, then Director of the Imperial Mycological Institute. The short-term policy was to be controlled inter-crossing of the most resistant cassava varieties available, and, as a long-term project, to study the resistance of other species of *Manihot* to the East African strains of virus; at the same time it was decided to attempt inter-specific hybridization. The classic example of the complete control of mosaic in sugar cane by the production of immune varieties by inter-specific hybridization of sugar cane *Saccharum officinarum* L. and *Saccharum spontaneum* L. (the latter a wild non-sugar producing species), encouraged the hope that similar results might be obtained through inter-specific hybridization of cassava and other Manihots. A start was made in 1937.

During recent years, selection work on cassava has been carried out by Agricultural Departments in all the East African territories. At the coast experiment station at Kibarani, in Kenya, variety trials and selection were started as far back as 1929. At that station a local variety known as "Malindi" was found to be more resistant to mosaic than any other variety, and subsequently it was used as a parent for raising new seedling strains there. When, however, this variety was tested at Amani its resistance proved to be inferior to that of some of our local varieties.

In Uganda, selection has been in progress for some years, and more recently this work has been concentrated at the Serere Experiment Station.

A number of field resistance trials were carried out at the Morogoro Experiment Station, in Tanganyika, and in about 1940 a considerable number of seedlings were raised from naturally pollinated seed.

Work on similar lines, using open-pollinated seed, was started by the Agricultural Department, Zanzibar, in 1941.

In the Belgian Congo, Opsomer (1939) raised several thousand seedlings, both from controlled crosses and from naturally pollinated flowers and tested them for mosaic resistance. He claims to have secured enhanced resistance but only in very few clones.

Koch (1934), in Java, appears to be the only other worker who has attempted inter-specific hybridization of the crop. He reports only limited success from crossing *M. utilissima* with *M. glaziovii* Muell.-Arg. (ceara rubber), and complete failure when the attempt was made to cross *M. utilissima* with *M. dichotoma* Ule. He named the F_1 *M. utilissima* x *B. glaziovii* hybrid *M. bogorensis*.

From the outbreak of war the progress of the breeding work at Amani was retarded, but it was possible for the programme to be continued but although only on a much reduced scale.

This account must be regarded purely in the light of an interim report because the work is far from complete. It will be some years before more comprehensive records are available as many varieties and forms of *Manihot* of different generations still have to be tested, and therefore only tentative conclusions can be reached at present.

Materials and Methods

In addition to *M. utilissima* Pohl. (cassava), the species available when the inter-specific hybridization work commenced were the following:—

M. glaziovii Muell.-Arg. (Ceara rubber).

M. dichotoma Ule.—(Jequie Manicoba rubber), introduced into East Africa by the Germans at the beginning of the century. A few of the original trees have survived to the present day.

"Tree" cassava.—This is here treated as a species for convenience. It is probably a natural hybrid between cassava and ceara. Specimens are to be seen in many parts of East Africa.

The following species were subsequently added to the collection:—

M. "cathartica".—From Botanical Gardens, Pietermaritzburg, South Africa.

M. catingae Ule.—From Brazil.

M. melanobasis Muell.-Arg.—From Surinam.

M. saxicola Lanj.—From Java

Of the above species *M. "cathartica"* proved to be highly susceptible to mosaic and therefore was not used in breeding. *M. catingae* has not flowered at Amani and only one plant of *M. melanobasis* was raised. The latter is a low-growing, slender form; its disease resistance cannot be ascertained until sufficient plants have been raised vegetatively.

The work involved can be conveniently reviewed under the following headings:—

(1) Seed production at Amani.

(2) Propagation and maintenance of seedling material at Amani. (Amani is particularly suited to this purpose because the vector population is low and natural infection is therefore limited.)

(3) Trials for field resistance to the mosaic and brown streak virus diseases in a locality where natural infection is known to be high.

(4) Immunity tests by grafting technique.

Seed production.—The manual operations involved in controlled pollination present no difficulties. Male and female flowers are produced separately on the same plant; natural pollination is effected by insects and possibly by wind. Flowers usually commence opening about 11 a.m. The flowers, both male and female are enclosed in muslin bags in the morning of the day they are due to open and pollination is carried out in the afternoon. After pollination the bags are replaced and labelled. A few days after pollination mosquito netting bags are substituted for the muslin bags to admit air and light to the developing fruits. It is esential to enclose the fruits in these bags because, when ripe, they dehisce explosively, scattering the seeds. Flowering may take place at any time of the year, depending on the weather and age of the plants, but the main flowering season is from December to March, and it is at this season that the greatest set of fruits is obtained. Parthenocarpy (production of fruits without fertilization) is very common, but fruits so formed contain no viable seeds. Fruits ripen in from three to five months. It takes three years to produce and test successive generations.

Propagation.—Under natural conditions the germination period of the seed may be protracted and erratic. This is due, presumably, to the very hard testa. Rapid and fairly uniform germination can be secured by carefully filing the micropylar end of seeds until the white embryo is just visible; a hand emery wheel is useful for this purpose. The seeds are then placed on moist sand in petri dishes in an incubator at 30°C. The majority of

viable seeds germinate in a few days but some may take up to a month; any taking longer than this may safely be considered non-viable; early growth of moulds on seeds may also be taken to indicate that the germ is dead. This method is practised here with consistent success.

The germinating seeds are potted as soon as the radical appears and transferred to a greenhouse where they remain until the seedlings are about six inches high; they are then moved to the open and hardened off prior to being planted out in a propagation plot. Under good growing conditions the majority of seedlings make sufficient growth in five to six months to permit of at least half a dozen cuttings being taken. As a rule four cuttings of each clone are planted in a maintenance plot to provide material for field trials and for future crossings, if required.

Field Trials.—As many hundreds of seedlings are raised and have to be tested, field trials for disease resistance are an essential part of selection. To be of any value these trials must be conducted in an area where primary infection is known to be high. Such an area was found at Kizugu, in the foot-hills of the Eastern Usambara mountains, at about 600 ft. above sea level and ten miles from Amani. Trials were conducted each year on this site from 1938 to 1945. With the extension of the breeding programme there was insufficient land at Kizugu to deal with all the material produced and it was necessary to find another suitable site. Through the courtesy of the Tanganyika Sisal Board, land has been put at our disposal at the Sisal Experiment Station, Mlingano, situated on the plains, some thirty miles from Amani and 600 ft. above sea level. An experiment conducted in the same locality some years ago demonstrated that the infection rate is high in that district, a conclusion which is confirmed in recent trials.

Field trials are carried out in two stages. First there is a non-replicated preliminary trial in which the varieties to be tested are planted at 5 ft. intervals between closely planted hedge-rows, 10 ft. apart, of diseased plants. Formerly only one diseased variety was used as a source of infection. As this variety may have carried only one strain of each virus (the existence of different strains of the mosaic virus has been recorded elsewhere (Storey and Nichols, loc. cit.), it was considered desirable to expose test plants to as many strains of disease as possible; therefore, in recent trials, three different diseased varieties, from three different localities, were used, and they were planted sequentially in the rows. This preliminary trial eliminates the more susceptible varieties which are then discarded from the collection. This reduces to manageable proportions the numbers to be subjected to a more critical test in replicated trials the following season.

The replicated trials carried out from 1938 to 1940 were on a triple lattice lay-out designed by Dr. Yates to carry 100 clones. The healthy cuttings were planted at 5 ft. spacing between diseased hedge-rows with a guard plant at each end of every row. There were 30 plants per row and 10 rows per block. Each "plot" contained one plant and each variety appeared three times in each of the three blocks so that nine replications were secured. In these trials great difficulty was experienced in assessing the morphological chraracters of varieties when each "plot" only contained one plant, and furthermore, the lay-out seemed unnecessarily complicated for our purpose. For these reasons, in later experiments, the design was modified to that of randomized blocks, replicated three times. Each block contained 60 plots and each plot five plants. The clones to be tested usually appeared once in each block. The area of land involved remained the same as for the previous design. Trials on these lines were carried out from 1940 to 1945, using the same land each year. When the results of these experiments were subjected to statistical analysis some perplexing anomalies were encountered which tended to reduce the value of the experiments. If a variety was included in any one trial more than once, in some cases a significant difference appeared between two or more groups of plants of one and the same variety. A possible explanation is that the degree of replication was insufficient. In the latest trials a further modification has been made without alteration to the area of land used whereby the replication has been increased from three to five and the plants per plot reduced from five to three.

Planting is usually carried out between October and December, depending on the rains. The vector population increases from then on, the peak infection period being in April and May during the long rains. With the onset of the cool season, following the rains, the vector population decreases and new infections decline. The experiments are terminated any time from July to September after eight to ten months observation.

The incidence of mosaic is recorded monthly from the date of planting. In the earlier experiments the figures assigned for resistance to this disease, for purposes of statistical analysis, were based on the total number of months the plants of each variety in each plot remained free from infection. In later experiments this system was modified, and now the number of months of healthy growth before the first plant becomes infected is taken as the index figure for each plot. This is a far more severe test and results in a greater proportion of clones being discarded in every trial. It can be quite logically argued that this method fails to make full use of all the available information and that it would be more equitable to take the mean number of months of healthy growth of all the plants in each plot as the index. The counter argument is that at this stage, where large numbers of clones are being tested, discarding should err on the side of severity and therefore the more drastic method is justifiable.

Certain diagnosis of brown streak is not always possible without some mutilation of the plant. Furthermore, stem and leaf symptoms (except in highly intolerant varieties), do not as a rule become evident until the onset of the cool season. For these reasons recording of this disease is done at harvesting when root symptoms can also be seen. Above- and below-ground symptoms are recorded separately and figures allocated on severity of manifestation.

Classification of results presents some difficulty. In earlier experiments clones were grouped according to their degree of resistance to mosaic, as shown by the total number of months the plants of each clone remained free from disease. For example, 15 plants of each clone in a trial terminated after eight months could be separated into five categories thus: 0-24, 25-48, 49-72, 73-96, and 97-120 months of healthy growth respectively; the first group would contain the most susceptible varieties and the last the most resistant. In the case of brown streak the classification was based on the totals of the figures scored for severity of symptoms.

These methods are arbitrary and sometimes led to confusion. Difficulties arose in both diseases in deciding where to draw the line between resistance and susceptibility in the intermediate classes and a better method of classification seemed desirable. A simple method was arrived at based on the figures obtained for significant difference (these are calculated at the 5 per cent level). Suppose the significant difference for the mosaic figures works out to be 2.0 in a trial lasting eight months. The means for those clones which completely escape infection will then be 8.0. All varieties can now be arranged in classes, according to their means, by successively subtracting the significant difference of 2.0 from the maximum mean of 8.0 in the following way:—

	Class I	Class II	Class III	Class IV	Class V
Means	8·0	7·9-6·1	6·0-4·1	4·0-2·1	2·0-0·0

It will be observed that there is no significant difference between classes I and II. The former contains only those varieties which completely escape infection (and would include those which were immune) and it is therefore obviously desirable to divide the 8.0–6.1 range into two classes to distinguish the former. A range of classes can be determined for brown streak in a similar manner except that in this case the mean for class I will be zero since the method of scoring is cumulative—the higher the score the more severe the effects of the disease. The figures for significant difference naturally vary from trial to trial and the number of classes may be less or greater than five, but this does not affect the basis of the classification.

This is the method of classification now being used. It at least has the merit of consistency in treatment and provides a standard means of deciding what to retain and what to discard. Varieties falling in class III or above are automatically discarded with the exception of abnormally high-yielding clones which are worth keeping for further crossing. On an average about 80 per cent of the varieties are discarded after each trial. As resistance is built up in successive generations and more and more clones fall into the class I category it should be possible to confine hybridization entirely to varieties in this class. At present some class II and III material is still being used in order to secure a wide range of types.

Since the two virus diseases are entirely distinct and are independent of each other, resistance to one does not imply resistance to the other. For instance, a given variety may be in class I for brown streak resistance and class IV for resistance to mosaic. Such a clone is normally discarded. Priority in selection is accorded to mosaic resistant clones, since this

disease is of more general occurrence than brown streak. Furthermore, on the experimental evidence available there is good reason to believe that resistance to brown streak can be secured more easily than resistance to mosaic.

It must be stressed that only in the case of complete immunity will the above described method of classification give absolutely consistent results. A slightly susceptible variety, for example, can quite conceivably appear in class I in one trial and in class II or even III in another. The same control variety, Mbarika, of intermediate resistance, has been included in all the eight replicated trials so far completed. On the mosaic resistance side it appears five times in class III, twice in class IV, and once in class V; the figures for brown streak resistance are once in class I, four times in class II, once in class III and twice in class V. Variations in classification of a particular variety from trial to trial can be accounted for, in part, by the presence or absence of particular virus strains in any given trial and also to chances of infection being influenced by fluctuations in the vector population due to natural causes beyond the experimentor's control.

Immunity Tests.—As reported elsewhere (Storey and Nichols, loc. cit.) all attempts to transmit mosaic by any of the known methods of mechanical inoculation failed, but consistent success was achieved by grafting. The leaf-graft technique developed by Nattrass (1944), working on the transmission of woodiness disease in *Passiflora* spp., has been tried without success. Had this method succeeded a considerable saving of space, material and labour would have resulted. Thus stem-grafting is the only method available. Failure to transmit a plant virus by grafting to plants of the same species or closely related species is generally accepted as proof of immunity. There are certain reservations to this statement which will be brought out later in this paper. Immunity tests are now carried out after completion of the field trials on material appearing in class I only.

The method which has been used here for a number of years with the greatest success is that which is generally known as the vertical top-cleft graft. Healthy and diseased cuttings are planted separately in 4–5 gallon galvanized iron buckets, in a greenhouse. Only one shoot is allowed to develop from each cutting of the plants to be tested. When these are about 2–3 ft. high the tops of the shoots are cut off at the point where bark formation is just evident and diseased scions of similar size and in a similar stage of growth are grafted on and bound with adhesive rubber tape. It is advisable to remove all but the youngest leaves from the scion. As a rule the bud at the node immediately below the graft develops, and if the plant is susceptible mosaic symptoms develop in this shoot. Brown streak symptoms generally occur in the main stem below the graft as well as on the new lateral shoot. If after union has taken place the stock fails to form a lateral shoot it can generally be induced to do so by cutting back the scion to the second node above the union. Mosaic and brown streak can be transmitted simultaneously by using a scion carrying both diseases; but it is advisable to transmit them separately because the effects of brown streak on non-tolerant varieties are such that growth may be completely arrested and therefore mosaic symptoms cannot develop.

Results

Results are summarized in tabular form as they become available. In view of the incompleteness of these results it is not proposed to publish them in full in this paper—but they are available to anyone interested.

Results are considered under the headings of fertility, morphology and resistance to virus diseases. Percent germination does not signify very much because some seeds produce a radicle and develop no further, others never get beyond the cotyledon stage, while in a further proportion stunted plants a few inches high are produced and these have to be discarded. In place of percent germination the term "percent success" is used. The denominator is obtained by multiplying the total number of flowers pollinated by three (since a fruit should contain three seeds), the numerator being the number of plants of a family surviving to reach the field, multiplied by a hundred. Unless otherwise indicated in every case in the crosses mentioned below the female parent is named first.

Cassava x *Cassava Crosses.*—Low seed fertility is a striking feature within this species. In individual families fertility ranged from zero to 56 per cent success, with a mean of 13.6 per cent for twenty-seven attempted crosses in the F_1 generation, and from zero to 55 per cent success with a mean of 14.6 per cent for thirty-two attempted crosses in the second generation. Last year over one thousand

seeds were produced by controlled pollination from specially selected parents, and distributed to agricultural departments for propagation and trial. The behaviour of the resultant seedlings is not yet known.

In the plants raised so far, considerable morphological variations occurred, even within the same family. Conspicuous variations were observed in branching habit, shape and colour of stem, colour of petiole, shape and size of leaflets, shape, size and yield of roots, and colour and texture of the root bark. No detailed records have been kept of these morphological differences because there appeared to be no obvious correlation between them and the resistance of particular clones to virus infection.

Resistance to mosaic and brown streak ranged from extreme susceptibility to high field resistance in a few clones, the majority, however, being in the susceptible category. Of the 331 clones in the two generations raised and tested, 39 (in 17 families), have been retained for further testing and breeding. Six clones are in class I and ten in class II for resistance to mosaic; three in class I and six in class II for resistance to brown streak. Unfortunately none of these highly resistant clones possesses any outstanding merit as regards yield. No cassava plant so far tested has ever withstood infection to either disease when subjected to infection by grafting.

Inter-specific Hybridization

"Tree" Cassava x *Cassava and reciprocal crosses.*—Only one specimen of "tree" cassava has been used. This variety produces very few female flowers and therefore only seven flowers were pollinated, all of which failed to set seed. The reciprocal cross, however, gave 6.9 per cent success with a total of 27 plants in four families. In the first back-cross to cassava 5.2 per cent success was obtained when the female parent was cassava and 1.8 per cent success for the reciprocal. F_1 hybrids crossed amongst themselves resulted in 6.7 per cent success. An improvement in fertility was noted in the second back-cross generation, the figures being 12.5 per cent and 8.5 per cent respectively, the higher figure when using cassava as the female parent.

The F_1 plants which survived to reach the field made excellent growth, some attaining a height of 20 ft. or more and equalling in vigour the "tree" cassava parent. Some individuals showed decided cassava characteristics, particularly in their root systems which were indistinguishable from those of cassava. Others possessed a high fibre content but in none was the root system entirely woody. After four years' growth a single plant of one of these hybrids yielded 100 lb. of edible root. There was some variation in the shape and size of roots throughout the F_1. Cassava characteristics were accentuated in the F_2 generation (first back-cross) and in the next generation the plants are almost indistinguishable from cassava. A very pronounced tendency towards the production of unbranched types occurs in these hybrids.

The parent "tree" cassava clone is in class I for resistance to both virus diseases; it has, however, been experimentally infected with mosaic by the insect vector. Nine clones of the F_1 generation plants were retained after field resistance trials, five of these were placed in classes I and II for brown streak resistance. Resistance was not particularly marked in the first back-cross and on this account all but three out of the 22 plants raised were discarded. A further group of this generation has been raised and is now being multiplied vegetatively. On the basis of the preliminary field trial the indications for resistance in an F_3 generation (second back-cross) are encouraging. Forty-three clones out of a total of 95, representing members of eight families, survived this trial, and they are now in replicated trials.

Ceara x *cassava and reciprocal crosses.*—Three generations (an F_1 and two back-cross generations) have been raised, the crosses being successful both ways. In the F_1 fertility was very low, being 0.4 per cent success for the ceara x cassava cross (only one plant raised) and 1.8 per cent for the reciprocal, giving 20 plants in four families. Koch (loc. cit.) failed in the ceara x cassava cross but, by calculating from his figures, he appears to have achieved 3.2 success in the reciprocal. Fertility improved in the first back-cross, the figures being 5.0 per cent success with cassava as the female parent and 3.0 per cent for the reciprocal. F_1 hybrids crossed amongst themselves resulted in 3.4 per cent success. In the second back-cross fertility was still better, the figures being 12.2 per cent when cassava was the female parent and 7.5 per cent for the reciprocal.

The majority of the F_1 hybrids were very vigorous and grew into tree-like forms, their habit resembling the ceara parent. Root systems were mainly woody, but some clones did produce intercalary tubers. The progeny

of the first back-cross was more variable, the habit ranging from dwarf forms to arborescent types showing ceara characters, intermediate forms and decidedly cassava-like types. There was corresponding variation in the root systems ranging from completely woody roots to tuberous roots of different shapes and sizes, with varying fibre content. One clone yielded a mean of 63 lb. of edible root after 14 months growth in the propagation plot. In the second back-cross a more pronounced trend towards the cassava parent was evident, both above and below ground. In all three generations a proportion of the progenies manifested various forms of undesirable leaf characters, such as general chlorosis, variegation and distortion of the lamina.

Half the F_1 clones were discarded after being tested for disease resistance, both in field trials and by grafting. In the grafting experiments, four clones resisted mosaic and two resisted brown streak infection, but in the field trials all became infected with mosaic; in some clones the symptoms were of a transient nature, one or two leaves showing symptoms and all subsequent growth being devoid of any visible trace of disease. In the first back-cross generation field resistance improved to the extent that six clones were placed in class I and six in class II for resistance to mosaic, with seven in class I and five in class II for resistance to brown streak. Of these clones three are in class I for resistance to both diseases. All three originate from the most resistant of the F_1 hybrids, but are the result of back-crossing with different varieties of cassava. One of these clones shows particular promise and it has been used in producing a large proportion of the F_3 progenies (second back-cross), some of which are now undergoing field trials. An open-pollinated group of F_2 seedlings showed poor field resistance and all except one clone was discarded.

M. dichotoma x *cassava and reciprocal crosses.*—This is the most interesting of the inter-specific crosses and in so far as it is possible to judge at this stage, the one which promises the best results. Three specimens of *M. dichotoma* and several cassava varieties (some of which subsequently proved to be highly susceptible to virus infection) were used in the initial crosses. Crossing was successful both ways. Koch's (loc. cit.) attempts to hybridize these two species were unsuccessful.

In the F_1 generation, using *M. dichotoma* as the female parent, eleven crosses were attempted resulting in 10.7 per cent success with a total of 16 plants in seven families. In the reciprocal only 1.8 per cent success was achieved, giving 16 plants in three families. Although some of these plants flowered freely and set fruits no seeds were formed and it was concluded that they were completely sterile. An attempt was then made to induce polyploidy (chromosome doubling) to restore fertility. Colchicine was used and various methods of applying it at different concentrations, ranging from 0.005 per cent to 1.0 per cent, to the developing buds of cuttings planted in a greenhouse, were tried with indifferent success. Some sectors of the meristematic tissues were undoubtedly affected in the early stages of growth, but the shoots soon lost their abnormal swollen appearance and it was assumed that if a change in the chromosome number had been brought about, the cells so affected had been swamped by normal tissues. The treated plants were put out into the field and left to develop. Further attempts to produce tetraploids by artificial means were abandoned because, in the meantime, some of the original F_1 clones set seed naturally, a proportion of which was viable and and from which an F_2 generation consisting of 54 plants was raised. A further seven plants were raised from seed set by the Colchicine treated plants, of these one was a triploid and the remainder diploids. The F_2 plants were growing in close proximity to other inter-specific hybrid material and also to cassava, and it is therefore idle to speculate on the origin of the pollen which effected fertilization. Attempts at controlled pollination met with limited success. Back-crossing to cassava as the female was successful with the pollen from only one F_1 hybrid (0.4 per cent success) from which three plants were raised, one of which appears to be completely sterile, one pollen sterile but ovule fertile and the remaining one fully fertile. These two plants produce very few flowers of either sex. No seeds were obtained from the reciprocal cross (F_1 hybrids x cassava) and intercrossing the F_1 hybrids was likewise a complete failure. The production of an F_3 generation by controlled back-crossing to cassava was much more successful. Using cassava as the female parent the figure was 21.9 per cent success and for the reciprocal it was 5.1 per cent. Ten families were raised with a total of 104 plants. In addition to the controlled crosses, seeds from naturally pollinated flowers of the F_2 hybrids was saved and germinated, from which a further 163

plants were raised. Production of an F_3 by further controlled crossing is in progress. An F_4 group of plants resulting from natural pollination has also been raised. Fertility in the F_3 generation now appears to be sufficiently satisfactory to warrant the discontinuation of propagation from open-pollinated seed.

Apart from stunted plants 2 to 3 in. high, which were discarded and another group 1 to 1½ft. high which were perfect specimens in miniature, the general appearance and size of the F_1 hybrids was intermediate between the two parents, irrespective of which way the cross was made. They were slow growing and most of them were difficult to propagate from cuttings. A notable feature is that under adverse weather conditions most of the plants retain their leaves far better than either of the parents. Without exception, the roots were woody, although a very thin starchy ring was discernible in a few plants. In the F_2 plants there is a considerable variation in habit ranging from cassava-like through intermediate, to types similar to *M. dichotoma*.

No particular significance can be attached to the morphology of these plants since, with the exception of the three plants mentioned above, the male parent is unknown. The roots of this generation were again predominantly woody, but in about 20 per cent of clones definite tuberous roots were formed. The appearance of the open-pollinated F_3 generation, as may be expected, is also very variable, but in the families raised by controlled pollination there is a definite trend towards greater uniformity in type, with cassava characters predominating at least in the aerial parts of the plants.

Vegetative propagation of *M. dichotoma* from cuttings is difficult. The F_1 hybrids, although more amenable in this respect, would not root very readily in the open. For this reason satisfactory replicated field resistance trials with this material were impracticable, but single plants of each clone of the F_1 hybrids, rooted in pots in a greenhouse, were planted out in the field trial plots between rows of diseased material and kept under observation for 22 months. All remained healthy. A single cutting from one of the parent *M. dichotoma* trees did root in the greenhouse and this plant was subsequently grafted with a mosaic diseased scion and it contracted the disease. About half the F_1 progeny originate from this parent. Twenty-two different plants of the F_1 generation were subjected to the grafting test with most satisfactory results.

The grafted plants were kept under observation for nine months and only one of these F_1 plants contracted mosaic, six developing brown streak, despite the fact that some of the cassava parents used in these crosses subsequently proved to be highly susceptible to mosaic and that one, at least, of the *M. dichotoma* parents was graft-susceptible.

The three plants raised by controlled pollination in the F_2 (first back-cross) were given replicated field trials with the result that two are placed in class I and one in class II for resistance to mosaic and one in class I and two in class II for resistance to brown streak. Two of these clones, however, are graft-susceptible to mosaic, but the third (the fully fertile one) so far has not been infected by any means; but it is graft-susceptible to brown streak. Turning now to the open-pollinated F_2 generation, consisting of 61 plants, of those so far tested eight have been placed in class I for mosaic resistance and five in class I for brown streak resistance. These plants are now undergoing grafting tests. The field classification of the second and third back-cross generations is not yet available, but some of the clones have been through grafting tests; nine of them withstood infection by mosaic, but of these some have become infected in the field trials now in progress; this indicates a difference in virulence between the strain of virus used in the grafting experiments and the strains in the field trials. Similar anomalies may be revealed in the case of brown streak when the recording of this disease is done at the termination of the trials.

M. saxicola x *Cassava cross.*—*M. saxicola* has proved to be highly susceptible to mosaic, and for this reason very little hybridization has been carried out with it. An F_1 family of 13 plants has been raised by crossing cassava (male) on to this species. These hybrids flower and fruit most prolifically and an F_2 generation of 340 plants has been raised from open-pollinated seed on the chance that some would be disease resistant.

These hybrids are mostly small-leafed types with slender, much-branched stems, in this respect they resemble the wild parent. The majority are low growing forms. The root systems range from woody to tuberous, the bulk being woody, but some have given quite good yields of tuberous roots.

It is worth while persevering with this material on the chance that the protein content of the roots of *M. saxicola* may be higher than that of cassava. If any clones show any degree of resistance further hybridization will be carried out.

Discussion

Although the results are incomplete, a stage has been reached where some useful conclusions may be drawn.

Fertility figures for the cassava x cassava crosses are low and the fact that certain crosses are completely sterile at once introduces a limiting factor in selective breeding. The large number of cassava forms in cultivation suggests that the species is highly heterozygous. If this is so, incompatibility probably plays a part in determining the fertility of particular crosses. The reasons underlying the low fertility recorded in the cassava crosses are, however, beyond the scope of this paper and it is not within my province to attempt to enlarge on the genetical implications of the problem. Cytological study would undoubtedly throw light on the issues involved; it might even locate the relative positions of the genes controlling those characters which it is sought to combine in a single individual. This information would be of assistance in deciding what crosses were likely to give the desired result.

Complete sterility in F_1 hybrids of inter-specific origin is of common occurrence but, as a rule, if this sterility can be overcome by artificial or fortuitous means fertility of future generations is more or less assured. This assertion is borne out by the figures presented for the various inter-specific crosses made. The increasing fertility obtained in the successive generations justifies the conclusion that no further difficulty is to be expected in raising future back-cross progenies, with the reservation that in particular crosses sterility analogous to that found in some of the inter-varietal cassava crosses may also be encountered.

The wide range of plant types already produced bears out the theoretical expectation that hybridization of heterozygous and of inter-specific material may be expected to result in considerable morphological variation in the offspring. In the earlier stages of this work morphology was of less importance than disease resistance and it was accordingly relegated to the background, but the stage has now been reached where morphological characters come into the picture. In this connexion high yield combined with quality must take first place. The results indicate that continued back-crossing of the resistant inter-specific hybrids will, in due course, restore normal tuberous root systems, and, it is hoped, without loss of resistance. Height, branching habit, density of foliage and shape and size of roots are of secondary importance, but with the range of material now available the chances of producing any desired type of plant appear to be favourable.

Apart from soil fertility and climate, the greatest factor militating against economic yields of cassava in East Africa is infection by mosaic and brown streak diseases. Immunity is obviously the ideal to be aimed at in breeding for disease resistance. If the attainment of immunity is likely to be protracted, or if it proves to be unattainable, the next best course is to try to secure high resistance, and if this breaks down the only other alternative is to select for tolerance, that is, select clones which though susceptible continue to give reasonable yields when they become infected.

The wide variation in the susceptibility of different clones, as shown by field trials, demonstrates quite conclusively that resistance is entirely independent of climatic and soil conditions. This being so it is reasonable to assume that genetical factors control inheritance of resistance. At present there is no indication of the nature of this resistance; it may be some inherent character of a clone which, under unknown conditions, repels the insect vectors, or it may be due to some biochemical reaction which destroys the virus when it is injected by the insect into the plant, the degree to which this inhibitory action is set up deciding whether a plant becomes infected or not. There is no experimental evidence for either of these hypotheses.

Although the number of cassava seedlings so far raised by controlled crossing must be considered small by plant breeding standards, there is hypothetical evidence that a greater measure of resistance than that already attained is unlikely to be obtained in this species. An African will never wilfully destroy a self-sown food plant, a fact which means that thousands of self-set seedlings come into existence every year and it is therefore not unreasonable to suppose that immune or highly resistant seedlings, if they gave good yields, would stand a very good chance of survival;

selection of such clones for propagation would follow as a matter of course. But no form of cassava has yet been found which is immune to mosaic, which suggests that if a factor or factors for immunity exist then the individuals carrying them do not survive, or if they do their yield is so poor that they are discarded. If, on the other hand, immunity factors have a lethal effect it is then obvious that immune varieties cannot be produced. Results to date show that high resistance is attainable, but there is no evidence that immunity will eventually be attained.

Turning now to the inter-specific hybrids. The success achieved in crossing no less than four different species of *Manihot* with cassava and the subsequent raising of fertile back-cross generations must be regarded as offering considerable scope for securing the desired combination of characters. So far the results show that at present high resistance, and not complete immunity, is all that can be expected of the crosses made between cassava and "tree" cassava and between cassava and ceara. In the case of the *M. dichotoma* hybrids, the evidence is that some individual clones of the F_1 and first back-cross progenies are certainly immune to particular strains of virus. It remains to be seen whether this immunity can be retained during further back-crossing, which is necessary to restore tuberous roots. Comparison of field results and grafting experiments have shown that the reliability of the grafting test to prove immunity is conditioned by the particular strain of virus against which a plant is tested. It is therefore impossible to state categorically that a clone is immune to all existing strains when infection does not take place as the result of grafting only one strain. The best that can be done is to use the most severe strain obtainable for these grafting tests. Potentially immune clones will then have to be put into field trials in different localities. A clone which remains healthy in all such trials, over a period of years, could then reasonably be regarded as immune to natural infection, but there would be no justification in assuming that it could not be infected by grafting particular strains.

Assuming that immunity is not obtained in any of the inter-specific hybrids when adequate tuberous roots have been restored by further back-crossing, but that high field resistance is secured, then another aspect of the problem has to be considered. All things being equal, a variety highly resistant to natural infection is admittedly better than a susceptible one, provided it remains healthy and is a good cropper, but it follows quite logically that such a variety, once it becomes infected, could quite conceivably be more affected than a tolerant susceptible variety. The chances of highly resistant varieties becoming infected would depend on the proximity of diseased plants and the prevalence of the insect vector. Elimination of the vector is virtually an impossibility and control measures based on the selection of healthy planting material appear to be impracticable on the scale necessary completely to eliminate foci of infection. Unless the cultivator can be educated up to planting cuttings only from healthy plants the distribution of resistant varieties, which may be badly affected, from the point of view of yield, when they do become diseased would, at best, have beneficial effects for a limited period only. If lack of care in selecting healthy material for planting continued the situation would finally become as bad, if not worse, than it is to-day, and the only remaining course would then be to select for tolerance.

Whatever the outcome of this work may be, even assuming that immunity is obtained in some of the inter-specific hybrids, the final consideration will have to be the requirements of the grower.

Quality is of prime importance; in this connexion the purpose for which the crop is produced must be taken into account. If the roots are to be used purely for making into flour, a high fibre content is no great disadvantage, but if they are going to be eaten raw or cooked as a vegetable, roots with too much fibre would not be acceptable. Palatability is also important. On the whole, sweet types seem to be preferred by the great majority of Africans, but bitter ones are popular in pig-infested districts because these animals do relatively little damage to bitter varieties, whereas they do extensive damage in plots of sweet varieties. The degree of bitterness is determined by the cyanogenetic glycoside content, which is said to be high in some varieties and therefore consumption of the fresh roots by human beings is potentially dangerous, unless the toxicity is first destroyed by cooking. That fresh roots of some of the inter-specific hybrids may prove to have high toxicity seems unlikely because at harvest time the labourers engaged eat them quite readily. Two samples of flour, one from a "tree" cassava hybrid and the other from an *M. dichotoma* hybrid, were submitted to the

Government Laboratory, Dar es Salaam, for analysis. No hydrocyanic acid was found in either sample, whereas 1.1 per cent was detected in a third sample which consisted of ordinary cassava flour. Comparison of the analytical figures were also highly satisfactory in other respects. There is some hope that an increase in the protein content may be obtained in some of the inter-specific hybrids.

Early maturity is highly desirable in some districts, while in others types which will remain in the ground for years without deterioration are wanted. The indications are that the latter type of plant will be found amongst the inter-specific hybrids.

It is therefore necessary to breed a wide range of types conforming to the needs of different districts covering a wide climatic range.

With this object in view it may take many years to produce the requisite range of immune, highly resistant, or, in the last resort, tolerant varieties required. To breed for immunity to one disease, coupled with desirable agronomic qualities, is in itself a long business, but when there are two diseases the time factor is inevitably increased.

Summary

An interim account is given of the materials and methods being used at Amani in an attempt to improve cassava (*Manihot utilissima* Pohl.) by selection and hybridization, with particular reference to resistance to the two virus diseases, mosaic and brown streak, which are the cause of heavy losses in yield in East Africa.

The first stage is the production of seed of both cassava and inter-specific hybrids by controlled pollination and multiplication of the seedlings by vegetative propagation, followed by preliminary and replicated field trials for disease resistance and cropping qualities. A method is described of classifying clones on the basis of their resistance to natural infection as reflected by statistical analyses of the results.

Successful inter-specific hybridization is reported between cassava and "tree" cassava (which is probably itself a natural hybrid between *M. glaziovii* Muell.-Arg. and cassava), *M. glaziovii* (ceara rubber), *M. dichotoma* Ule, and *M. saxicola* Lanj. Back-crossing to cassava was successful and the third generation has been reached by this means. The fertility, morphology and disease resistance of these hybrids is discussed.

Field trials show that there is a wide range between the resistance of different clones to the two diseases. Highly resistant forms of true cassava and of inter-specific hybrids have been produced; results indicate that complete immunity in all but the *M. dichotoma* hybrids is unlikely to be obtained. In some of these hybrids immunity to particular virus strains is demonstrated; it is not yet known whether this immunity will be retained through continued back-crossing which must be carried on until normal tuberous root systems are restored. It is stressed that the efficacy of the grafting test to prove immunity is conditioned by the particular virus strain used; immunity to one strain does not automatically imply immunity to other strains, the implications of this fact are brought out in the discussion.

Acknowledgments

Thanks are due to Sir Geoffrey Evans, Economic Botanist at Kew, for assistance in securing for us seeds of different species of *Manihot*; to Dr. Yates and other members of the statistical branch of Rothamsted Experiment Station, for advice on the design of field experiments and statistical interpretation of the results; to Mr. L. R. Doughty, then of the Amani staff, for assistance in determining chromosome counts in certain of the hybrid material and, later, for supervision of the hybridization work and field trials during the war years; to numerous departmental officials for supplying planting material of promising varieties. Finally, I am indebted to Dr. H. H. Storey, F.R.S., and Mr. J. D. Jameson, of Uganda, for encouragement and much helpful advice during the past two years. The work described was started by Dr. Storey with myself as junior collaborator, but for the past two years the work has been carried out by me.

References

Briant, A. K., and Johns, R., 1940.—Cassava investigations in Zanzibar. *East African Agric. Journ.* 2, 404.

Koch, L., 1934.—Cassaveselectie. *Veenman and Zonen*, Wageningen, 1934.

Nattrass, R. M., 1944.—The transmission of the virus of the "woodiness" disease of passion fruit by single leaf grafts. *Ann. Appl. Biol.* 31, 310.

Opsomer, J. E., 1939.—Technique et premiers résultats de l'amélioration du manioc à Yangambi. *Agric. et elev. au Congo Belge.* 13, 4.

Storey, H. H., 1936.—Virus diseases of East African Plants—VI. *East African Agric. Journ.*, 2, 34.

Storey, H. H., and Nichols, R. F. W., 1938.—Studies of the mosaic diseases of cassava. *Ann. Appl. Biol.* 25, 790.

Storey, H. H., 1939.—Report of the Plant Pathologist. *Rep. E. Afr. Agric. Res. Stn.*, 1939, p. 9.

CHARCOAL MADE IN FORTY-GALLON DRUMS

By J. F. Hughes, Assistant Conservator of Forests, Tanganyika Territory

(*Received for publication 30th November, 1946*)

Charcoal of good quality can be produced at a low cost in kilns made from forty-gallon drums. Notes on the construction of two types of oil-drum kiln are given here, together with instructions for their operation.

Australian Model

(*Diagram* 1)

This is a modified version of a kiln first developed in Australia, where it was used to produce charcoal for producer gas vehicles.

Material required.—A 40-gallon drum, four $\frac{3}{8}$ in. bolts about $1\frac{1}{4}$ in. long, four large-headed $\frac{3}{8}$ in. bolts about $1\frac{1}{4}$ in. long.

Construction.—The bottom of the kiln is removed by cutting around the inside of the rim. Four holes $\frac{3}{8}$ in. in diameter are drilled about 2 in. below the rim in the positions indicated by the letters A, B, C and D (Diagram 1); $\frac{3}{8}$ in. bolts are inserted from the outside and fastened with nuts on the inside, leaving about $\frac{3}{4}$ in. of the bolt projecting towards the centre of the drum. Four more holes are then drilled about 1 in. below the level of the rim at the positions indicated by the letters E, F, G and H. The bottom can now be replaced to rest on the bolts A, B, C, D, and be held firmly in place by large-headed bolts inserted from the inside at E, F, G and H, and then fastened on the outside with nuts.

The two plugs are removed and two additional holes 2 in. in diameter are cut to make a regular pattern of four openings on the lid. Flat iron plates are made to fit over these holes.

Operation.—The drum is placed bottom upwards on four bricks on a couple of 1 in. pipes and the bottom removed. A fire is lit inside and fed with dry fuel until it covers the whole of the surface of the lid (now at the bottom). Ventilation is provided by the four holes on the lid and the draught is controlled by banking earth around the edges of the drum. When the fire is burning brightly the drum should be filled with dry billets of wood 3 feet long and 3 in. to 4 in. thick. As this wood burns down the drum is rocked to shake down the burning embers, thereby keeping the fire compact and evenly spread. The charge is knocked down with a hammer to assist in this process, and as it falls below the level of the rim shorter pieces of wood are added. To obtain the best results, a slow steady fire is required, and the draught may have to be controlled by banking earth. After about two hours the drum is ready for reversal. The bottom is replaced and held in position with bolts E, F, G and H, and the drum is then turned upside down on an old sack with the aid of a shovel. It is allowed to stand until thick white smoke has stopped issuing from the vents on the lid (about two or three hours). The vents are covered with iron plates and sealed with wet earth. The bottom of the drum is completely banked up and it is left overnight to go out. A yield of from three-quarters to one bag per run should be obtained.

If a large proportion of the charge is unburnt this is probably due to insufficient care in obtaining a compact, evenly spread fire before reversal. Reversal tends to throw an uncompacted fire to one side, with the result that burning continues down one side only, leaving an unburned section on the opposite side. Uneven burning can be detected by the temperature of the outside of the drum. If any section appears to be unduly cool, more vigorous burning should be promoted there by shutting off the other lid vents for a time.

South African Model

(*Diagram* 2)

Material required.—A forty-gallon drum, three feet of six-inch stove pipe, a few square feet of thin sheet iron (the sides of an old forty-gallon drum will do).

Construction.—The drum is placed on its side so that the small plug hole A is vertically above the large plug hole B. Rectangular holes are cut at C (9 in. by 8 in.), D (5 in. by 3 in.) and E (3 in. by 3 in.). A sheet-iron cover is made to fit over C, being held in place by a pair of lugs riveted to the drum. At E a sliding hatch is fitted so that the size of the opening can be regulated. The chimney section, consisting of a three-feet length of six-inch stove pipe fitted to a square sheet-metal base, is erected over D. It is held in position by two sheet-iron lugs.

Operation.—The kiln is packed tightly with billets of wood 8 in. long and 3 in. to 5 in. in diameter. Care must be taken not to block the air inlet E, or the chimney hole D. Dry kindling fuel is placed at A, and it is important that the charge should be packed evenly at this end of the drum in order to ensure an even burn. The fire is kindled at A and when it is burning strongly across the whole of the end of the drum, A, B and C are closed. The chimney is then erected over D and sealed on to the drum

with clay. Burning is continued until all the wood opposite the air inlet E has been comuletely carbonized. The chimney is then removed and replaced by a plate which is sealed on to the drum with clay. All other openings are closed and sealed in a similar manner, and the kiln left for about three hours to cool down before opening. The yield is from half to three-quarters of a bag per run.

If the charge is only partly carbonized opposite C this shows that a stronger fire should have been allowed to develop before closing A, B and C, and erecting the chimney. Unburned wood opposite D indicates that the kiln has been closed down too quickly or that it was not correctly packed in the first place.

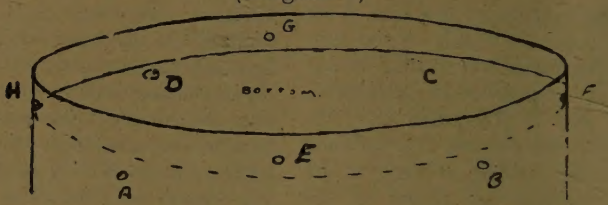
Selection and Preparation of Wood for Charcoal Burning

Dense hardwoods produce the best grade of charcoal, and the billets should be as dry as possible to obtain the maximum yield. To aid in drying out, the bark should be removed before stacking. In any case, bark is undesirable, since it gives the charcoal a high ash content. Billets should be cut to size to suit the type of kiln. For any one charge they should all be of the same species of approximately the same moisture content, and about the same diameter.

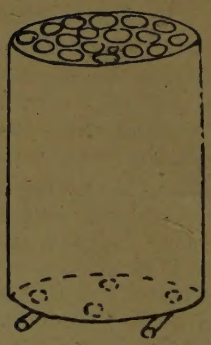
A note will be published later on the suitability of various local woods for charcoal production.

AUSTRALIAN MODEL

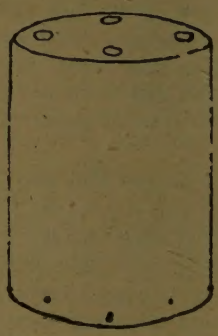
(Diagram 1)



Method of fixing the bottom



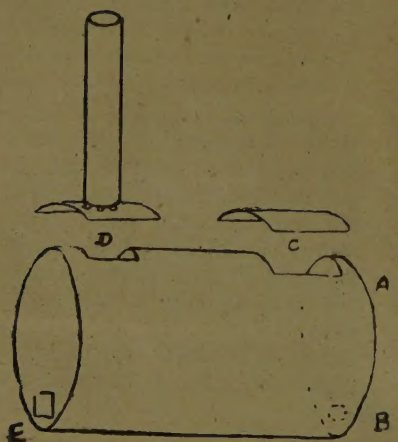
Before reversal



After reversal

SOUTH AFRICAN MODEL

(Diagram 2)



Method of fixing chimney section